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# Teachers College RECORD

Vol. XXVII, No. 6 February 1926

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In honor of

EDWARD LEE THORNDIKE

on his

Twenty-fifth Anniversary

as Professor in Teachers College

February 1901—February 1926

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# TEACHERS COLLEGE RECORD

VOL. XXVII, No. 6 FEBRUARY 1926

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# TEACHERS COLLEGE RECORD

VOL. XXVII NO. 6

February 1926 Number

In Honor Of

## Edward Lee Thorndike

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# INTRODUCTORY NOTE

CAN the thought and life of a man ever be interpreted adequately by those around him? This volume scarcely dares attempt an answer to that question. It tries to record rather than to interpret the work of a great American scholar, carried on among us for a quarter of a century. The record has been compiled by students and colleagues, primarily as a tribute, but also as an instrument of scholarship; for a mere personal tribute, not also of use to others, would seem in the present instance to be inappropriate.

Nearly all now living, who have taken the doctorate degree under Professor Thorndike's guidance, have contributed to our common labor. Some were too far away in remote parts of the world when the matter was first undertaken. A few found themselves too overwhelmed at the moment by demands of immediate duty. One was snatched away by death in the very midst of his participation in the task.

In accordance with the respect for individual differences, which we have learned perforce, no attempt has been made to press the work of the contributors into the same mold of expression. Each has been allowed to vary as he would, despite a certain resulting heterogeneity.

It rarely happens that a scholar may accomplish twenty-five years of productive work at a time when another quarter of a century still lies clear before him. The record here presented is a prophecy, rather than a history, of achievement. Indeed, as this volume goes to press, recent important investigations, carried forward in the Institute of Educational Research, are on the eve of publication. Among these are extensive additions to knowledge concerning the nature and the measurement of intellect.

UNIV. OF MICH.

E. L. Thorndike

# VITA

EDWARD LEE THORNDIKE was born in Williamsburg, Massachusetts, August 31, 1874. His father was Edward R. Thorndike, his mother Abby B. (Ladd). He has two brothers, Ashley, born 1871, now Professor of English, Columbia University, and Lynn, born 1882, now Professor of History, Columbia University, and one sister, Mildred, born 1890, now teaching in the Evander Childs High School, New York City.

Professor Thorndike prepared for college in the Roxbury Latin school. He took an A.B. degree in 1895 at Wesleyan, and in 1896 at Harvard, followed by A.M. in 1897 from Harvard and Ph.D. in 1898 from Columbia University. Thereafter he became Instructor at Western Reserve, 1898-99, then Instructor in Genetic Psychology, Teachers College, Columbia University, 1899-1901. In 1901 he was made Adjunct Professor of Genetic Psychology in Teachers College, in 1902 Adjunct Professor of Educational Psychology, in 1904 Professor of Educational Psychology, the title being changed in 1923 to Professor of Education. He has also received honorary degrees of Sc.D. in 1919 from Wesleyan, LL.D. in 1923 from Iowa University.

In 1925 Professor Thorndike was the recipient of the Butler medal in gold, which is awarded every five years for the most distinguished contribution made during the preceding five-year period anywhere in the world to philosophy or to educational theory, practice, or administration: "Awarded, for his exceptionally significant contribution to the general problem of the measurement of human faculty and to the application of such measurements to education."

In August 1900 he married Elizabeth Moulton, A.B. of Boston University. His children are Elizabeth Frances, born 1902, A.B. with honors Vassar 1921, A.M. Columbia 1924; Edward Moulton, born 1905, getting his A.B. from Wesleyan in 1926; Robert Ladd, born 1910, graduating from Horace Mann School for Boys, with honors, 1926; and Alan Moulton, born 1918.

# I. Personal Appreciations

## THORNDIKE AND TEACHERS COLLEGE

THE *Teachers College Record,* as its name indicates, is intended to carry to our alumni a record of what the College is doing. For twenty-five years it has been more or less successful in portraying the material accomplishments of the institution, but no mere printed statement can adequately reflect the spirit of the place. The spirit of the College, that something which gives it personality and marks it for our own, is embodied in the lives of the members of our staff. There is a reason, therefore, why this number of *The Record* should be devoted to the life and works of one man—one whose term of service is contemporaneous with the life of this journal and whose personality has pervaded the institution from the day he entered it to the present moment. In developing the subject of educational psychology and in making it a fit study for students in all departments, Professor Thorndike has shaped the character of the College in its youth as no one else has done and as no one will ever again have the opportunity of doing. It may be too early to weigh properly the results of his work, but it is not too soon to give his friends and students this opportunity to pay their tributes to a man whose teachings already have a sure place in the history of education.

My acquaintance with Dr. Thorndike began with a visit which I made to his classroom in Cleveland where he taught the year following the taking of his doctor's degree in Columbia University. I knew of him as a student who had made a study of the behavior of monkeys—a pretty good stepping-stone, it seemed to me, to a study of the nature and behavior of children. At that time neither the term nor the subject of educational psychology had been created; but I had a notion that a field of study so obviously fundamental to educational theory and practice should have both a name and a sponsor in the kind of teachers college which I was planning. After listening to one class exercise, I was satisfied that I had found the

right man for the job. I promptly offered him an instructorship and he as characteristically accepted it at once. Whether he has ever regretted such unseemly academic haste I do not know, but I do know that no hour of my life has been more profitably spent. Quick to size up a problem, however novel and strange it might appear, clear and direct in his thinking about it, almost uncanny in his methods of approach to a solution of it, prompt and positive in giving his conclusions once he had worked his way through it—these traits were as characteristic of him at the beginning of his career as they have come to be peculiarly his own in later years. These traits would have made him a leader in finance, in industry, or in trade, had he chosen to give himself to business instead of to science and education. His mental equipment and his methods of work would make for success in almost any field of human endeavor.

To me, however, it is Professor Thorndike's personality that makes the greatest appeal, a personality that most markedly differentiates him from men of small caliber and really constitutes his true greatness. Were he to lack this something which is so hard to define, he might have been both a clever and an efficient leader but lacking, nevertheless, in those qualities which endear him to his colleagues and make him a great teacher. It is his open-mindedness, his native honesty, his sympathetic understanding, his good judgment, his readiness to spend himself for others, his abounding good will and genial coöperation in every undertaking that have given him the place he holds in the affections of all who have had the good fortune to come under his influence. Teachers College has had and still has a goodly number of great teachers, men and women of intellectual power and professional strength, all of whom will gladly join with me in this tribute to one whom we delight to honor and for whom we wish another quarter of a century as full of riches as the past twenty-five years have been.

JAMES E. RUSSELL

## THORNDIKE AS COLLEAGUE AND FRIEND

WILLIAM JAMES once said to me that Edward Thorndike, more than any other whom he knew, had the quality most essential to a scientific man or an artist, which he explained was the ability to see things apart from acquired perspective and personal reference. Genius has been attributed variously to natural endow-

ment, to opportunity, and to hard work; but of these, as Thorndike has maintained, hereditary equipment is the fundamental factor, for it in large measure creates the opportunity, the training, and the habits. Odin found that French men of letters come from favorable surroundings, and concluded that genius is in things and not in men. Galton had earlier found that genius displays itself in family lines and attributed it to heredity. The fact appears to be that what a man can do is prescribed at birth; what he does is dependent on circumstance.

Thorndike has himself contributed strong evidence for the combined potency of heredity and environment by the fact that his two brothers are leading professors in the same university of which he is himself a large part, and there is good ground to predict that his children will provide similar testimony. As statistics collected by me show, an infant has the best chance to become a leading scientific man if he finds a clergyman for his father, who should, as in the case of Thorndike's, be a man of ability.

William and Henry James, like Thorndike and his brothers, were sons of a student of divinity. He did not become a practising clergyman, but was a Swedenborgian theologian and a brilliant man of letters. The two sons were among the hundred ablest Americans of their generation: the probability that such an occurrence could be due to chance is disappearingly small. But their careers apparently indicate that genius as such is inherited, while the individual is so plastic to circumstance that the work that he accomplishes, and even the character that he acquires, may be due in large measure to the environment to which he responds. So the performance of Thorndike, made possible by his native endowment, must be attributed on the one hand to the good fortune of his opportunities at Teachers College, and on the other hand to hard work and readiness to "seize the skirts of circumstance."

Wesleyan College was a good place for an able boy in the nineties, as it still is, and Thorndike had the sense to repeat his senior year at Harvard and to remain for a year as a graduate student in a university where were James, Royce, Palmer and Münsterberg. He then came to Columbia, bringing with him his work on chicks and cats. James had let him keep the chicks in the cellar of his Irving Street house, but I doubt whether he had much to do with the inception or conduct of the work. I am sure that I had only to provide for the boy of twenty-three a corresponding retreat in the

attic of Schermerhorn Hall and to let him alone until he had produced the doctorate thesis which is the foundation of a quantitative science of animal behavior. This work was continued later with monkeys and other animals; it foretold and directed the work that has since been done to the time of the most recent rats and the chimpanzees of Yerkes and Köhler.

After receiving his doctorate, Thorndike migrated for a year to Western Reserve University. Dr. Russell had become dean of Teachers College, and its great development began. By the agreement with Columbia University I became professor of psychology. On the credit side of the ledger, balancing all possible debits, must be written my part in bringing Thorndike to the College. It was at first planned to call a man better known in education, but Thorndike came and with him the influence and the career known to us all.

The twenty-six years that have since elapsed have witnessed the development both of professional schools of education and of educational psychology as a science. It is always difficult to determine whether historical movements are due to social and economic forces in which those prominent are epiphenomena, or whether they are caused by great men who lead them. However that may be, it is impossible to write the history of education or of psychology without giving prominence to Thorndike's name. In these fields we are in advance of all nations, and the benefits from their cultivation extend to every one. In presenting Thorndike recently for an honorary degree at the University of Iowa, Dean Seashore truly said: "No school is uninfluenced and no humanistic science is unaffected by his labor."

I am warned that I must not infringe on the fields of others, but should confine what I write to Thorndike's early days at Columbia, his influence on the University, and our personal relations. The department of psychology for many years formed the closest connecting link between the Columbia and the Teachers College corporations, in which Barnard College may be included, for psychology has always been a harmonious unit undisturbed by administrative conditions. There was a free interchange of class work and students, so that the place of registration made no difference. The department was the first to admit fully women from Teachers College and Barnard College to its classes and laboratories, Dr. Norsworthy, Dr. Whitley, and Dr. Hollingworth being among those to whom doctorates were awarded.

Thorndike's loyalty to Teachers College has thwarted efforts—not mine, for I should have known their futility—to bring him across 120th street. His counsel and example have, however, been a benefit throughout the University. In educational and administrative problems Teachers College has often led. A minor instance may serve as an example. Columbia had a sabbatical year on half salary, but that benefited as a rule only those who had independent means or no family. I proposed as an alternative a half year's leave with full salary. This is an advantage to the teacher, with no drawback to the institution beyond its more general application. The plan was vetoed for the University, and then Thorndike proposed it to the Dean and Trustees of Teachers College. After it had been adopted there, the University followed.

Thorndike was fortunate in having Woodworth as a fellow student and a fellow worker at Harvard and at Columbia. Each has had an appreciable share in the position attained by the other. Their joint laboratory work on the transfer of training was of fundamental importance. They became two of the five psychological members of the National Acadamy of Sciences, another being Professor Dewey. Professor Boas was at that time a member of our department, and we learned much by association with him.

Thorndike for long years attended my seminar, and research work was discussed in common. We established together the New York Branch of the American Psychological Association in affiliation with the New York Academy of Sciences. Thorndike has been president of both the association and of the academy. The most active psychological center, made such in large measure by Thorndike himself, has been a considerable influence on all who shared in it. It is from give and take with others that we learn the most; not chiefly from what they tell us, but rather from what we are led to tell them.

It is a satisfaction that I have never had any slightest difficulty with any student or psychological colleague. My relations with Thorndike have been more intimate than with any other, except possibly Boas and Woodworth. Our interests and viewpoints in psychology and in education have coincided to an unusual degree, not perhaps because either learned from the other, but, let us hope, because each of us recognized the right end and the right way. There has also been a considerable accord in political, social, and economic questions, though not perhaps in methods, the dike in Thorndike being more in evidence than the thorn.

We have coöperated in many ways. He was for a time associated with me in the editorship of the *Popular Science Monthly* and has assisted in the work of other journals. His books on Educational Psychology and on Mental Measurements, and several of his monographs were published in series that I edited. The Psychological Corporation, established several years ago to forward research on an economic basis and to advance a profession of psychology, includes in its organization all leading American psychologists and most of those active in psychology. Since its foundation, Thorndike has been chairman of the directors, and I have been president. It may not be generally known that he was the first to establish an office for professional psychological practice, and that among the first industrial psychological tests were those he instituted for the Metropolitan Life Insurance Company.

The some thirty books and three hundred articles by Thorndike witness the almost incredible amount of work that he has accomplished. I have met him twice recently away from home. On the Twentieth Century train a porter delivered to me a special delivery letter addressed to Professor Thorndike, though why he selected me as the professor I do not know. I found Thorndike, who had given a hundred lectures in the West, checking from memory in a book that he was reading the words not included in his list of the ten thousand most common words. At the Cosmos Club in Washington, when we parted for the night after a long day of committee meetings, he was going to his room to study Ido, in order better to conduct experiments on learning. But he can play as well as work. The Thorndike service is still a tradition at Wesleyan, and we play tennis, billiards and bridge, not to speak of nights at the theater and at the club and café when such places had more attractions than now.

Thorndike established a colony in view from my house, where, among others, have lived in the summer or through the year Woodworth, Woodbridge, the Hollingworths, Poffenberger, and Keppel. It once required a day for a visit: now the motor car has made us neighbors, and our children can continue family traditions. It is not in the outside world but at home that we come to know one another. Even more than many books and much reputation are kindness and courage. The most nearly ultimate goods of life can be shared by all—home, friends, things to do, freedom, self-respect. But there are not many to whom it is given to enjoy them so fully as does Thorndike.

J. McKeen Cattell

# II. Annotated Chronological Bibliography of Publications by E. L. Thorndike

Every effort has been made to have this bibliography complete; but, even so, some few reviews may have escaped the attention of the committee. While going to press another important book is expected, viz.: *The Measurement of Intelligence.* Bureau of Publications, Teachers College.

KEY TO ABBREVIATIONS

Am. Econ. Rev., American Economic Review. A. J. P., American Journal of Psychology. Amer. J. Pub. Hlth., American Journal of Public Health. Amer. Nat., American Naturalist. Am. Phys. Ed. Rev., American Physical Education Review. Arch. Psy., Archives of Psychology. Bkmn., The Bookman. Ch. St. Mo., The Child Study Monthly. Col. Contr. Ed., Columbia Contributions to Education. Col. Contr. Phil. Psy. Ed., Columbia Contributions to Philosophy, Psychology and Education.

Ed. Adm. Sup., Educational Administration Supplement. Ed. Record, Educational Record. Ed. Rev., Educational Review. El. Sch. J., Elementary School Journal. El. Sch. Tchr., Elementary School Teacher. Engl. J., The English Journal. Guernsey Brdr. J., Guernsey Breeders' Journal. Intnl. Mo., The International Monthly.

J. An. Behav., Journal of Animal Behavior. J. Appl. Psy., Journal of Applied Psychology. J. Ed. Res., Journal of Educational Research. J. Ed. Psy., Journal of Educational Psychology. J. Exp. Psy., Journal of Experimental Psychology. J. Ped., Journal of Pedagogy. J. Phil. Psy. Sci. Meth., Journal of Philosophy, Psychology and Scientific Method.

Math. Tchr., The Mathematics Teacher. Mo. Wthr. Rev., The Monthly Weather Review. Ped. Sem., The Pedagogical Seminary. Pop. Sci. Mo., The Popular Science Monthly. Psy. Bull., The Psychological Bulletin. Psy. Clin., The Psychological Clinic. Psych. Rev., The Psychological Review.

Sch. Home Ed., School and Home Education. Sch. and Soc., School and Society. Sch. Sci. and Math., School Science and Mathematics. Sch. Rev., School Review. Sci. Amer., The Scientific American. T. C. Bull., Teachers College Bulletin. T. C. Record, Teachers College Record.

## 1898

ANNOTATED BY BENJAMIN R. SIMPSON, PH.D. 1912, Professor of Psychology, Cleveland School of Education.

1. Animal Intelligence. *Psych. Rev. Mon. Suppl.* 2:109pp. Also *Col. Contr. Ed.* 4:3. Macmillan Co., New York.

The career of a scientist is usually foreshadowed by the early production of a piece of work of prime importance. This is well exemplified by the above-mentioned doctor's dissertation, published at the age of twenty-four.

The work started as an investigation of the facts of association in animals. It was the work of a pioneer. It exhibited genius in its clear grasp of vital problems, and of the facts needed for their solution. It invented the precise method for securing the necessary facts, thus establishing the technique for comparative psychology. The solution of problems was paralleled by the formulation of additional ones whose method of solution was definitely indi-

cated. It was inevitable that such work should open up this whole virgin field for extensive development and stimulate enthusiastic workers to follow up the newly blazed trail. The publication of *Animal Intelligence* marks the real starting point of animal psychology as a science.

Yet its greatest value doubtless lay in its contribution to a new viewpoint in general and in educational psychology. It clearly revealed the fallacy of the old structural viewpoint, and went far towards establishing upon the Stimulus-Response cornerstone the foundation for a dynamic psychology, emphasizing as it did, bonds and specific connections as the central factor in all learning. It bridged the gap between human and animal psychology, and by illuminating the genesis of human faculty greatly simplified our understanding of it.

2. Some Experiments on Animal Intelligence. *Science* n. s. 7:818–26 (June).

3. Note on Animal Intelligence. *Psych. Rev.* 5:645–50 (November).

These are general statements concerning the experimental studies on Animal Intelligence, summarizing the main findings.

4. Review of (*a*) Hall: *Study of Fears.*

5. Review of (*b*) Hall and Allen: *The Psychology of Tickling, Laughing and the Comic.*

6. Review of (*c*) Lindley: *A Study of Puzzles.*

7. Review of (*d*) Street: *A Study of Moral Education.*

8. Review of (*e*) Lindley and Partridge: *Some Mental Automatisms.*

*Psych. Rev.* 5:87–90 (February).

The review of Hall's *Study of Fears* contains this comment: "More fruitful than a host of questionnaires would be a set of experiments on children from birth on, in circumstances where their experience of and instruction about things could be regulated and its influence as a disturbing factor completely known. Then an instinctive act would be unmistakable." This statement is of particular interest in view of Watson's recent investigations of the instinctive and emotional reactions of infants.

9. Review of Evans: *Evolution of Ethics and Animal Psychology. Psych. Rev.* 5:229–30 (March).

10. Recent Changes in the Studies Required for the A. B. Degree in Colleges for Women. *Western Reserve Univ. Bull.* n. s. 2:73–86.

This article scores the tendency to do much theorizing about trends in college courses and factors at work upon them without an adequate basis in fact, and amply illustrates how the theories could be checked up by the facts.

11. What Is a Psychical Fact? *Psych. Rev.* 5:645–50 (November).

Munsterberg's contention that "the psychical fact as such is for philosophical reasons just as undescribable as it is unmeasurable," is exposed to the light

of the noon-day sun. The illumination is so intense that no smoke-screen of philosophical abstraction could longer cloud the issue. Nothing is left of Munsterberg's contention.

## 1899

ANNOTATED BY BENJAMIN R. SIMPSON, PH.D. 1912, Professor of Psychology, Cleveland School of Education.

12. An Experimental Study of the Associative Processes in Animals. Biological Lectures from Woods Hole Marine Laboratory. Athenaeum Press. pp. 57–91. Ginn and Co., Boston.

These lectures clarified the current interpretation of instincts by the addition of many specific facts.

13. Do Animals Reason? *Pop. Sci. Mo.* 55:480–90 (August).

In the light of the facts here presented and of the technique used, this long-debated question is essentially settled. Further advance in the solution becomes merely a matter of extending the application of the technique as suggested by the author.

14. The Instinctive Reactions of Young Chicks. *Psych. Rev.* 6:282–91 (May).

15. A Note on the Psychology of Fishes. *Amer. Nat.* 33:923–26.

The investigator everywhere finds opportunity to carry on new experiments. It is interesting to note the simple but effective method used in studying the learning of fishes. "By using long aquaria (with movable partitions) one can study the formation of very complex series of acts. Delicacy of discrimination of the fish in any respect may be tested."

16. A Reply to "The Nature of Animal Intelligence and the Methods of Investigating It." *Psych. Rev.* 6:412–20 (October).

This is a characteristic reply to a criticism. The issue is met directly, fully, objectively. The interest is solely in arriving at the scientific truth. The attitude is never one of personal controversy.

17. Mental Fatigue. *Science* n. s. 9:712–13 (May).

A preliminary report.

18. Sentimentality in Science Teaching. *Ed. Rev.* 17:57–64 (January).

"I don't try to teach children facts . . . I don't care how much they know about animals and plants if only they love them." The sentiment of the quotation was freely expressed by many teachers of elementary science at the time. How antagonistic this attitude is to the true spirit of science with its dependence upon facts, is brought out with characteristic clearness and vigor.

19. Reading as a Means of Nature Study. *Education* 19:368–71 (February).

The value of reading as taught in school may be greatly increased by an appreciation of its many possible objectives, and by a systematic effort to secure

them, instead of leaving the matter to chance. For example, one may secure by reading an elementary knowledge of human nature facts.

## 1900

ANNOTATED BY CLIFF W. STONE, PH.D. 1908, Professor of Education, State College of Washington, Pullman, Washington.

20. Reviews on Comparative Psychology. *Psych. Rev.* 7:202–06 (March).

Reviews of six studies that augur well for the progress of psychology toward a science.

21. Judgments of Magnitude by Comparison with a Mental Standard. (With Woodworth.) *Psych. Rev.* 7:344–55 (July).

Experimental evidence that apparently discredits Weber's law.

22. Mental Fatigue I. *Psych. Rev.* 7:466–82 (September).

A statement of the various theories and a record of experimental study strongly supporting the theory that mental fatigue is attested, not by inability to continue mental work, but by "certain extraneous results" such as "feeling bored, sleepiness, headache which are the results of the activity." This study opened up large possibilities, some of which have been followed out by the author and corroborated by Heck.

23. Mental Fatigue in School Children. *Psych. Rev.* 7:547–79 (November).

Record of extensive measurements exploding the myth that the mental ability of school children decreases from early school hours to the latter part of the school day. Part III shows "that mental work effected no decided decrease of physical power."

24. Instinct. Woods Hole Lecture 5:pp. 57-68. Ginn and Co., Boston.

Presents "the abilities to respond to different situations (more particularly certain complicated external situations) which the animal has to start with, apart from parental or self tuition."

25. The Associative Processes in Animals. Woods Hole Lecture 6:pp. 69-91. Ginn and Co., Boston.

A study of the learned activities of animals with special reference to the association of acts with the feeling-results of impulses. Animals do not rise to the level of association of ideas.

26. The Parent as a Factor in Mental Development. *Ch. St. Mo.* 5:299–305 (January).

Address: Parents should broaden children's experience both of things and people; and establish potent ideas and habits.

27. Some Data Concerning the Value of Latin as a Secondary School Subject. *J. Ped.* 13:27–38 (June).

Limited questionnaire data. "On the whole it seems fair to say that this

investigation puts the burden of proof on the advocates of the study of Latin. . . ."

## 1901

ANNOTATED BY CLIFF W. STONE, PH.D. 1908, Professor of Education, State College of Washington, Pullman, Washington.

28. The Human Nature Club. The Chautauqua Press, New York.

29. The Human Nature Club. 2nd edition enlarged. Longmans, Green & Co., New York. Pp. iv+235.

An exposition of functional psychology; its physiological basis, inherited connections, the different ways of learning, apperception, attention, etc. Written in conversational form and with a content that clearly forecasts the author's comprehensive educational psychology, this book still ranks as one of the two best first texts in dynamic psychology for immature students.

30. The Mental Life of (the) Monkeys. *Psych. Rev. Mon. Suppl.* No. 15. Also *Col. Contr. Phil. Psy Ed.* 9:1. Macmillan Co., New York.

A continuation of the experimental study of the intelligence of animals to answer: "(1) How do the monkeys vary from other mammals in the general mental functions revealed by their methods of learning? (2) How do they vary from adult civilized human beings?"

Extensive data on three "subjects" show that monkeys learn more, and more rapidly, than other animals but that they probably do not have "the power of forming associations of ideas to any greater extent than the other mammals." They represent progress toward man: "(1) In their sensory equipment, in the presence of focalized vision. (2) In their motor equipment, in the coordinate movements of the hand and the eye. (3) In their instincts or inherited nervous connections, in their general physical and mental activity. (4) In their methods of learning or associative processes."

31. The Intelligence of Monkeys. *Pop. Sci. Mo.* 59:273–79 (July).

Experimental evidence that monkeys learn by chance success impelled by their own impulses rather than by tuition, but that nevertheless "the monkey justifies his inclusion with man in a separate mental genus."

32. The Evolution of Human Intellect. *Pop. Sci. Mo.* 60:58–65 (November).

Based on experimental study of animal intelligence.

Concludes that "the intellectual evolution of the race consists in an increase in the number, delicacy, complexity, permanence, and speed of formation of associations (between situation and response). In man this increase reaches such a point that an apparently new type of mind results, which conceals the real continuity of the process"; but "nowhere more truly than in his mental capacities is man a part of nature." . . . "Amongst the minds of animals that of man leads, not as a demigod from another planet, but as a king from the same race."

33. Adaptation in Vision. *Science* n. s. 14:221 (August).

This phenomenon makes probable a complexity of brain mechanism not heretofore recognized.

34. Review of Titchener's *Experimental Psychology*. *Sch. Rev.* 9:484 (September).

Recognizes the book as an excellent manual for teaching "analysis of feelings into mental elements," and shows that it disregards "the great majority of our mental activities."

35. The Failure of College Women to Marry. "Educational Problems." *N. Y. Evening Post* (September).

College women marry late, especially those from women's colleges.

36. Syllabi of Courses in Elementary and Applied Psychology. *T. C. Record* 2:4:275–322 (September).

"An account of the required courses in pure and applied psychology at Teachers College" with syllabi.

37. Notes on Child Study. Macmillan Co., New York. Pp. 181.

Presents the then reliable findings of child study, with suggestive practical exercises; sounds the death knell to the then current twaddle of opinion; affords bases for "definite general principles about their (children's) physical and mental characteristics," thus enabling students of child nature to check and supplement their more intuitive knowledge; is notably dynamic in point of view; intended for immature students.

38. The Study of Children. *T. C. Record* 2:3:165–274 (May).

An account of work in the department of psychology in Teachers College; and a presentation of important data on Child Study. Interpretations of and annotated selections from investigations of children's reading, the aesthetic emotions, hand work, motor ability, spelling, punishment, heredity and environment. This study presages the author's educational psychology volumes.

39. The Influence of Improvement in One Mental Function Upon the Efficiency of Other Functions. (With Woodworth.) *Psych. Rev.* 8. (1) Plan and Conclusions of Study, and Area Tests—247–61 (May). (2) The Estimation of Magnitudes—384–95 (July). (3) Functions Involving Attention, Observation, Discrimination—556–64 (November).

This is the first systematic study of transfer and it still holds a prominent place among the few scientific studies of that field. The tests here made were confined to measuring "the influence of improvement in a function on *other functions closely allied to it*," thus supplementing the conclusive studies of Wissler and Norsworthy. The conclusions are: (1) General changes as such do not occur. (2) Functions are not exercised within narrow limits as units. (3) "Improvement in any single function need not improve the ability in functions commonly called by the same name." (4) Change in data effects change in function.

40. Review of Small's *Experimental Study of the Mental Processes of the Rat*–II. *Psych. Rev.* 8:643–44 (November).

Questions Small's conclusion that the rat was guided by images and feelings of recognition, and expresses belief that impulse is the more probable source of learning.

## 1902

ANNOTATED BY MILO B. HILLEGAS, PH.D. 1912, Professor of Education, Teachers College, Columbia University.

41. Correlations Among Perceptive Processes and Associative Processes. *Psych. Rev.* 9:374–82 (July).

A report of the correlations found between certain mental functions that are apparently closely similar. Results showed them to be to a larger extent independent specializations.

42. Marriage Among Eminent Men. *Pop. Sci. Mo.* 61:328–29 (August).

A study of the conjugal condition of eminent men to determine their attitude toward marriage. Compared with the whole male population, gifted men marry as young and in about the same proportion as the multitude.

43. Psychology in Secondary Schools. *Sch. Rev.* 10:114–23 (February).

A critical description of four types of courses in psychology that might be used in high schools. The article ends with a prediction that "a course in the scientific study of human behavior will probably be the last to enter our secondary schools."

44. The Experimental Method of Studying Animal Intelligence. *Intntl. Mo.* 5:224–38 (February).

The article describes some ways in which the author applied the experiment method to the study of the mental capacities of different groups of vertebrates. Results show a clear evolution of the animal sort of learning continuing through the human species. Below man, conduct is not modified by a stock of ideas.

## 1903

ANNOTATED BY FREDERICK G. BONSER, PH.D. 1910, Professor of Education, Teachers College, Columbia University.

45. Careers of Scholarly Men in America. *Cent. Mag.* 44:153–55 (May).

A study of the percentages of Phi Beta Kappa men entering the professions from 1840 to 1900, with a prediction of the distribution for subsequent years.

46. Educational Psychology. Lemcke and Buechner, New York. Pp. vii+173.

The first coherent attempt to assemble the known facts and working

methods of "a general dynamic psychology." It applies the "logic of statistics" to the study of education and illustrates methods of investigation by which the author and his students have made their numerous contributions.

47. Heredity, Correlation and Sex Differences in School Abilities. (Editor of.) *Col. Contr. Phil. Psy. Ed.* II:2:60. Macmillan Co., New York.

Eight papers by Professor Thorndike and his students from Teachers College. Introduction by Professor Thorndike.

48. Notes on Child Study. 2nd edition. *Col. Contr. Phil. Psy. Ed.* 8:181. Macmillan Co., New York.

Slight modification from first edition, and new sections on specialization of abilities, heredity and environment, sex differences and exceptional children.

49. Notes on Psychology for Kindergartners. *T. C. Record* 4:5:45–76 (November).

A discriminating treatment of psychological facts and laws having practical meaning for the education of young children.

50. Syllabus of a Course of Six Lectures on Fundamental Problems in Human Nature. *Teachers College Extension Syllabi Series B:* No. 8:10.

Contributions to the study of human behavior—mental evolution, growth, heredity, and abnormalities; environmental influences; and sex differences in mental traits.

51. The Decrease in the Size of American Families. *Pop. Sci. Mo.* 63:64–70 (May).

A discussion of the reasons for the decrease based upon the size of the families of graduates of four American colleges.

## 1904

ANNOTATED BY M. R. TRABUE, PH.D. 1915, Professor of Education, University of North Carolina, Chapel Hill, N. C.

52. An Introduction to the Theory of Mental and Social Measurements. The Science Press, New York. Pp. xii+212.

Statistical methods serve to simplify and to relate masses of data in such ways as will reveal their significance most clearly. This volume by Thorndike served much the same purpose in making clear to workers in education and in other social sciences the statistical methods that are most useful in the interpretation of mental and social data. Previous books, which had presented statistics chiefly as a developing science, had traced the mathematical derivation and proof of each method and formula, but had given few suggestions as to the practical uses of these methods. This volume, prepared specifically as a guide and aid to those who might desire to employ statistical methods in fruitful interpretations of human life and activity, immediately became the professional Bible of students interested in the scientific aspects of the social

sciences. The high quality of the scholarship which entered into the task is evidenced by the fact that for two decades the volume stood without a peer in its field.

53. Review of Hall's *Adolescence.* *Science* n. s. 20:142–45 (July 29).

In this review Thorndike called the attention of his fellow scientists to Hall's serene confidence in the validity of the "questionnaire method"; to an unwarranted characterization of William James as one who "throws scientific caution to the winds"; to the indistinct and imaginative character of Hall's presentations of the doctrines of recapitulation and of catharsis; to the remarkable combination of medical lore, erotic poetry, and inspirational preaching in Hall's discussions of sex; to the tremendous amount of labor required to assemble the materials quoted; and to the baffling junction in the same sentence or paragraph of statements which in "commonplace minds" have no relation whatever.

54. The Newest Psychology. *Ed. Rev.* 28:217–27 (October).

This review of Hall's *Adolescence,* being addressed to the educational public, neglects certain of the criticisms made in the review previously published in *Science* and emphasizes the immaturity of the psychological theories presented by Hall. It also suggests that much of Hall's practical advice on educational problems was derived from other sources than these inadequate theories.

55. Review of Scott's *Theory of Advertising.* *J. Phil. Psy. Sci. Meth.* 1:666 (November).

56. Review of Kirkpatrick's *Fundamentals of Child Study.*

57. Review of King's *The Psychology of Child Development.*

58. Review of Watson's *Animal Education.*
*Ed. Rev.* 27:199–202 (February).

Attention was called here to "the confusion of really reliable scientific work with the most amateurish opinion," especially in child study.

## 1905

ANNOTATED BY CHARLES H. ELLIOTT, PH.D. 1914, Professor of Education, Rutgers College.

59. The Elements of Psychology. A. G. Seiler, New York. Pp. xix+371.

In Part I, Descriptive Psychology, the author describes the subject matter of psychology under such rubrics as feelings of things present (sensations and percepts), feelings of things as not present (images and memories), and feelings of facts (relationships, meanings and judgments). Part II, The Physiological Basis of Mental Life, is devoted to a brief, thoroughly scientific description of the central nervous system. Forty-three reproductions from photographs and drawings of the finer nervous structure based upon a careful selection from an extended range of sources are included. Nervous conduction and connec-

tion forming are fully described. Part III is devoted to Dynamic Psychology defined as the science of the mind in action. Instincts are unlearned connections. Learning is controlled connection forming. A comprehensive law of association is stated and by means of this and the laws of dissociation and partial activity learning is explained and unified. Rejects ideo-motor theory. The book contains thirty simple experiments and lists of exceptionally well constructed exercises are a part of each chapter in Part I and of eight chapters in Part III.

60. The Selective Influence of the College. *Ed. Rev.* 30:1–11 (June).

The elimination of students from thirty-four colleges is studied by two methods: (1) the comparison of class populations; (2) the comparison of class permanences. Combining figures from both methods he concludes median continuance in college to be: to sophomore year 79 per cent; to junior year 58 per cent; to senior year 66 per cent. Suggests that freshman and sophomore courses should be general rather than introductory. Recommends study of withdrawals from college.

61. Measurement of Twins. *J. Phil. Psy. Sci. Meth.* 2:547–53 (September 28).

A summary of the results obtained from measuring fifty pairs of twins. Preliminary report based on investigation reported under next title.

62. Measurements of Twins. The Science Press, New York. Pp. vi+64. *Arch. Phil. Psy. Sci. Meth.* No. 1 (September). Also *Col. Contr. Phil. Psy.* Vol. XIII, No. 3.

Fifty pairs of twins 9 to 15 years of age attending New York public schools were measured with six mental tests. Eight physical measurements were made also. Data were carefully corrected for variability and attenuation. Mental measurements indicate resemblance for twins about twice that for siblings: Resemblance for twins 9 to 11 years approximately equal to that for twins 12 to 14 years (raw coefficients .75 and .64). Average correlation for mental traits is .78; approximately equal to average (.76) for physical traits. Resemblance in traits much subject to training, slightly greater than for traits little subject to training. Study gives new evidence of importance of original nature in determining behavior and achievement.

63. The Quantitative Study of Education. *The Forum* 36:443–48 (January).

Development of quantitative work in education is dependent upon knowledge of variable quantities and their use in measurement. Scales, commensurate units, and zero points not now available for measuring school work. Measurement of relationships needed to solve educational problems. Need for trained men to make scientific studies in public school systems.

64. What Instruction in Educational Psychology Should Be Given in a Professional Course for Teachers? *T. C. Record* 6:20–41 (January).

Recommends a course which emphasizes (1) connection forming, instincts

and capacities, association and abstraction of elements, (2) topics basic to a theory of education and teaching technique, and (3) special psychology of childhood. Presents outline with sample exercises of a year's course in general and educational psychology offered at Teachers College. Methods of teaching course described.

## 1906

ANNOTATED BY (MRS.) CLARA CHASSELL COOPER, PH.D. 1920. [Psychologist in Horace Mann School, New York, until 1921.]

65. Principles of Teaching. A. G. Seiler, New York. Pp. xii+293.

This pioneer work, which bases the principles of teaching upon the laws of psychology, is still modern. Methods employed or suggested in the text in common use to-day are exercises, the definition of teaching in terms of stimulus and response, true and false statements, tables of distribution, graphs, the comparison of individuals in terms of test results, completion tests, and the experimental determination of the best method of teaching a subject. Theories held by the author still associated with his name include the importance of natural tendencies, the necessity for exercising desirable tendencies and rewarding them with satisfaction, the desirability of education for originality, the existence of a general and fairly high correlation between many capacities, the existence of wide individual differences in original nature, the importance of mind "set," the desirability of adapting subject matter to the intellectual and practical needs of children, the similarity of the sexes in intellectual capacities, the importance for moral training of the formation of useful habits, the falsity of the common view of formal discipline, the possibility of the transfer of training through identical elements, and the necessity of testing the results of teaching.

This book has since been translated into Chinese.

66. Sex in Education. *Bkmn.* 23:211–14 (April).

Points out that differences between the sexes customarily supposed to be innate, are due to present social and industrial conditions and an unfair selection of representatives. The greater variability of the male sex is a difference educationally significant.

67. The Opportunity of the High Schools. *Bkmn.* 24:180–84 (October).

The high school can and should be better fitted to boys and girls, for example, to the poor and to the thing-thinkers; and also it can and should fit pupils better for life; for example, for the franchise, for self-support, and for maternity.

68. A Sociologist's Theory of Education. *Bkmn.* 24:290–94 (November).

Criticises Professor Ward's advocacy of all knowledge for all men. Suggests that more rational than increasing opportunity haphazard for all, would be giving added opportunities to the gifted, training the less gifted in the arts and industries, and improving society through eugenics.

69. An Empirical Study of College Entrance Examinations. *Science* n. s. 23:839–45 (June).

Presents data from Columbia College students showing that achievement in entrance examinations is totally inadequate to prophesy achievement in college, and indicating that a fairly large percentage of students shut out because of failure would have done better in college than a third of those admitted.

70. The Future of the College Entrance Examination Board. *Ed. Rev.* 31:470–83 (May).

Recommends that the College Entrance Examination Board, instead of depending upon the present entrance examinations, which are highly inaccurate, credit schools on the basis in each case of a systematic record of the actual success in college of the candidates endorsed in the past by that school.

71. Résumé of an address on Heredity. *Am. Phys. Ed. Rev.* 11:104–105 (June).

Shows that home training accounts for little of the resemblance found in twins. Since heredity is an important factor in physical education, whether education for health, skill, strength, or grace, recognition of this fact should make physical education more effective.

72. Review of *Mental and Moral Heredity in Royalty* by Frederick Adams Woods. *Science* n. s. 23:693–94 (May).

73. Review of *Applied Sociology* by Lester F. Ward. *Science* n. s. 24:299–301 (September).

The desirable consequences of the equalization of intellect advocated by Professor Ward may be gained as well, if not better, by its increase.

## 1907

ANNOTATED BY THOMAS H. BRIGGS, PH.D. 1913, Professor of Education, Teachers College, Columbia University.

74. Elements of Psychology. Second edition. A. G. Seiler, New York. Pp. x+351.

Only minor corrections from first edition.

75. Empirical Studies in the Theory of Measurement. *Arch. Psy.* No. 3 (April), *Col. Contr. Phil. Psy. Ed.* Vol. XV, No. 3. Science Press, New Pp. 45.

Four studies of measurements of type and variability: 1. The comparative accuracy of the average and the median; 2. The comparative accuracy of the mean square deviation and the average deviation; 3. The divergencies of the obtained from the true measures by theory and by experiment; 4. The relation between the amount of a central tendency and the amount of the variability of the group about the central tendency.

Five studies of the measures of relationship: 1. The meaning of typical measures of relationship; 2. The presuppositions of measures of relationship; 3. The advantages of the different measures; 4. The attenuation of measures of relationship; 5. Minor advice to students of mental and social relationships.

76. Accuracy from the Viewpoint of the Psychologist. *Education* 27:458–66 (April).

Inaccuracies, variable and constant, are in part due to inborn capacity; our problem is to make accuracy pay, preferably by intrinsic motive; accuracy is specialized, chiefly because it is almost always subordinated; we need more accuracy in the study of the humanities; "one of the chief developments of college education in the future will be the application of as exact methods of study, of record, of treatment, of all the humanities, as have been given to mathematics in the past"; for gaining accuracy "apply your discipline to something where accuracy really makes a difference."

77. A Neglected Aspect of the American High School. *Ed. Rev.* 33:245–55 (March).

Emphasizes by data from *Report of United States Commissioner of Education* for 1904 the preponderance of very small high schools and the great variability in size; concludes, therefore, that different provisions should be made for their programs.

78. On the Function of Visual Images. *J. Phil. Psy. Sci. Meth.* 4:12:324–27 (June). Also No. 7 of a volume of pamphlets. Lancaster, Pa.

Report of a rough experiment showing "no reason for belief that what we call knowledge about the visual aspects of things is to any considerable extent dependent upon our visual images of them."

79. The Mental Antecedents of Voluntary Movements. *J. Phil. Psy. Sci. Meth.* 4:2:40–42 (January). Read before the American Psychological Association, December 29, 1906.

Five arguments against the theory "that a mental state, to be efficient, shall *be* like what it *does* or *brings to pass*."

80. The Elimination of Pupils from School. *U. S. Bur. of Ed. Bul.* No. 4, 1907. Whole No. 379. Department of the Interior: Bureau of Education. Government Printing Office, Washington. Pp. 63.

A study of the elimination of pupils from public schools in 23 cities of the United States, by age, grade, sex, and color; of eliminations in 49 city high schools, and in 34 colleges.

81. Introduction to the Statistical Tables. Report of United States Commissioner of Education for the Year ended June 30, 1907. II:523–41.

An interpretation of the statistical tables, in the form of a partial balance sheet of the nation's investment for education.

## 1908

ANNOTATED BY PAUL J. KRUSE, PH.D. 1917, Professor of Education, New York State College of Agriculture, Cornell University.

82. Memory for Paired Associates. *Psych. Rev.* 15:122–38 (March).

Twenty-two adults learned English meanings of 1200 German words. Showed markedly more rapid learning and greater retention than earlier studies had indicated. No demonstrable improvement in capacity to form associations. Little variation of methods of study.

83. The Effect of Practice in the Case of a Purely Intellectual Function. *A. J. P.* 19:374–84 (July).

Twenty-eight individuals multiplied mentally one three-place number by another at the rate of 5 or 6 a day; 96 in all. Group became able to do the task in two-fifths of the time first taken; "the earlier periods of practice show the greatest gross reduction of scores"; "the largest individual differences increase with equal training."

84. A Pragmatic Substitute for Free Will. In *Essays Philosophical and Psychological in Honor of William James,* pp. 585–610.

Maintaining that meliorism—which according to James is the only issue of consequence in the free will controversy—is possible "without any need of our going against, or even beyond, the scientific, matter-of-fact point of view and habit of interpreting the universe," the author contends that the "changes for the better" are brought about within the narrow limits of our instinctive responses and the habits built thereon, through the selective influence of satisfyingness and annoyingness in relation to the world as a whole. Pointing out that "satisfyingness and annoyingness can only select, not create," the author anticipates much of the criticism of his Law of Effect in learning, which criticism holds that the satisfyingness consequent upon an act can have no effect on the connection involved in that act.

85. Review of Ribot's *Essay on the Creative Imagination. Ed. Rev.* 35:198 (February).

"The book is . . . an analysis of some of the facts of creative thought preceded by an exposition of reproductive and productive imagination in the technical sense."

86. Review of Major's *First Steps in Mental Growth. Ed. Rev.* 36:314 (October).

Reviewer welcomes the book as an "addition to the mental life-histories of babies, among which it ranks high"; states that author's "point of view is that of one interested in the nature of the 'mental states' in so-called structural psychology, rather than in the connections between situations and responses, in so-called dynamic psychology or the natural science of human behavior."

87. Review of Thompson's *Brain and Personality*. *Ed. Rev.* 35:307–308.

By pointing out grossly misleading statements the reviewer makes it clear that he does not find well founded the author's thesis "that purposive thought and action are not produced or paralleled by the activities of the central nervous system but are due to the direct creation by 'personality' of changes in the nervous system."

## 1909

ANNOTATED BY MARVIN J. VAN WAGENEN, PH.D. 1918, Lecturer in Education, University of California.

88. Influence of the Number of Men Teachers upon the Enrollment of Boys in Public High Schools. *Ed. Rev.* 37:71–85 (January).

The first large scale use of statistics of educational changes measured separately for single units indicated that neither the proportion of men on the high school teaching staff nor the feminization tendency has had any significant influence on the proportion of boys to girls in attendance or graduating.

89. The Teaching Staff of Secondary Schools in the United States. *U. S. Bur. of Ed. Bull.* No. 4:1–60, Whole No. 404.

A statistical analysis of data collected through the United States Bureau of Education bearing on salaries, education and experience of men and women teaching in the public and private secondary schools of the United States. Men teaching in public high schools have less education but are better paid than women, yet continue teaching but little longer. In private secondary schools, which have increased less rapidly and pay somewhat smaller salaries, the education of the women teachers is greater than that of men, but their salaries are proportionally less than in public secondary schools. The full effect of experience upon teaching efficiency is reached in three years.

90. Darwin's Contributions to Psychology. *Univ. Cal. Chron.* 12:1:65–80. An address delivered at the Summer Session of the University of California.

An analysis of Darwin's influence upon the problems and methods of psychology both through his direct contributions to psychology and through his contributions to all human thinking.

91. A Note on the Specialization of Mental Functions with Varying Content. *J. Phil. Psych. Sci. Meth.* 6:239–40 (April).

Correlations between measures of different content involving the same process are corrected for attenuation to show the existence of marked variability of performance at different levels within the same function.

92. The Relation of Accuracy in Sensory Discrimination to General Intelligence. *A. J. P.* 20:364–69 (July).

Low correlations between measurement of sensory discrimination and estimates of general intelligence refute Spearman's view of 1904 of a general factor in intelligence.

93. A Note on Accuracy of Discrimination of Weights and Lengths. *Psych. Rev.* 16:340–46 (September).

Experimental data are assembled to show the futility of attempting the derivation of any one psycho-physical law to explain the relation of the amount of inaccuracy of sense discrimination to the magnitude used as a standard. While the doctrine that inaccuracy of sense discrimination is proportional to the magnitude used is refuted by measurements, wide individual variations, changes with practice and specialization in content, evidence many specialized tendencies to response in opposition to any one psycho-physical law.

94. Exercises in Arithmetic, Selected, Graded and Arranged to Meet the Requirements of the Hygiene of the Eye and Neuro-Muscular Apparatus. A. G. Seiler, New York. Ex. 1 through 5.

A series of five short textbooks in arithmetic for grades through 5, in which provision is made for the formation of number habits and the gaining of arithmetical insights in accordance with recognized principles of educational psychology. One of the earliest attempts to apply principles of educational psychology in constructing the content of a textbook.

95. The Feminization of American Education. Vermont State Teachers Association, pp. 48–62 (October). (Not available.)

## 1910

ANNOTATED BY AGNES L. ROGERS, PH.D. 1917, Professor of Education and Psychology, Bryn Mawr.

96. The Contribution of Psychology to Education. *J. Ed. Psy.* 1:5–12 (January).

The contribution of psychology to education is to define the aim of education and to increase understanding of methods of teaching. It includes important topics for education, such as mental measurement, the investigation of individual differences and innate and acquired capacities, and the study of infancy, childhood and adolescence.

97, 98. Promotion, Retardation, and Elimination. *Psy. Clin.* 3:232–42; 255–65 (January, February).

The relative time required to complete each grade in elementary and secondary school is determined from data for 100 cities and towns for over one to five years. A critical comparison of methods of estimating the amount of promotion, retardation and elimination indicates that Ayres's procedure for estimating elimination is faulty. It is urged that systems of promotion should be in general more flexible.

99. Collegiate Instruction. *Science* 31:428–31 (March).

A statistical analysis of the size of classes in seven representative colleges shows that great variability exists. The percentage of the total degree require-

ment given to each subject by 500 students in 16 colleges reveals the prevailing extent of specialization. Standards for size of college classes are suggested.

100. Repeaters in the Upper Grammar Grades. *El. Sch. Tchr.* 10:409–14 (May).

A statistical study of the percentage of repeaters in the last three grammar grades in ten cities. Retardation is shown to be as great in late as in early grades with the exception of Grade 1.

101. The Relation Between Memory for Words and Memory for Numbers and the Relation Between Memory Over Short and Memory Over Long Intervals. *A. J. P.* 21:487–88 (July).

The correlation between immediate memory for words and immediate memory for numbers amounted to .45 ± 1, in the case of 30 educated adults. The correlation between memory over short and memory over long intervals for the same persons was .55 ± 1. This is one of the closest relations found in human nature.

102. Practice in the Case of Addition. *A. J. P.* 21:483–86 (July).

Improvement due to thirty to seventy minutes, practice in addition by 19 students was 31 per cent in time reduction and 29 per cent in error decrease. Initial ability and improvement correlated —.25. Individual differences in improvement ranged from 0 to 50 per cent. The method of the practice experiment is recommended for schoolroom use.

103. Handwriting. *T. C. Record* 11:2:1–81 (March).

This contribution of historic importance describes in detail the method of construction of scales for handwriting, laying the scientific basis for scaling schoolroom products in general. Part II analyzes the speed and quality of handwriting in seven school systems, discussing such problems as individual differences within the same system, and the relation of differences in results to difference in methods of teaching.

104. William James. *J. Ed. Psy.* 1:473–74 (September).

An appreciation of William James as psychologist, as teacher, and as man.

105. Education A. Notebooks. Teachers College, Columbia University, New York.

A manual to be used in an introductory course in educational psychology. Psychological principles are printed; blank space for illustrations and novel exercises are provided for use by the student.

106. Educational Psychology. Second Edition. Teachers College, Columbia University, New York.

This is a revised and enlarged edition of the volume of the same title published in 1903 [see ref. 46] giving a quantitative treatment of educational psychology. Two new chapters are added on the influence of race on indi-

vidual differences and the nature and amount of individual differences in combinations of traits; and three chapters on original and acquired traits, the influence of special training upon more general abilities, and the relationship of mental and physical traits are omitted. Changes have been made in the content of the chapters retained. New material based on work done between 1903 and 1910 has been incorporated, and there are minor alterations in organization.

## 1911

ANNOTATED BY M. THEODORA WHITLEY, PH.D. 1911, Assistant Professor of Education, Teachers College, Columbia University.

107. Animal Intelligence. Macmillan Co., New York. Pp. viii+297.

Mostly an assembling of earlier publications of the results of experimental work on cats, dogs, chicks, fishes and monkeys. See references 1, 14, 15 and 30. Chapter I is new, emphasizing the importance of objective study of behavior rather than depending merely on introspective studies of consciousness. Chapter VI contains his best-known formulations of the laws of exercise and effect, somewhat elaborated from the earlier statement in his *Elements of Psychology,* 1905. The discussion on imitation is largely incorporated in the first volume of his *Educational Psychology,* 1913.

108. Individuality. Houghton Mifflin Co., Boston. Pp. x+56. (Riverside Educational Monograph.)

Three chapters on the nature, causes and significance of individual differences. Distribution curves and quality profiles are plentiful; a full outline at the end analyzes the contents. Discredits the idea of the existence of types; reiterates that all qualitative differences are ultimately quantitative and therefore subject to measurement. A characteristic philosophy of life is expressed in the two concluding paragraphs.

109. The Emotional Price of Peace. *Amer. Ass. for Internat. Concil.* No. 45 (August). Pp. 11.

Reminiscent of James's article on the moral equivalent of war. Emphasizes the need of having satisfying substitutes for war, with suggestions for training interest in worth while citizenship.

110. Mental Fatigue. *J. Ed. Psy.* 2:61–80 (February).

The report of an extended experiment with sixteen adult subjects, using rapidity and accuracy scores in mental multiplication as a measure. Five tables are given. Little connection was found between acute feelings of fatigue and actual loss of efficiency in the process.

111. Testing the Results of the Teaching of Science. *Sch. Sci. and Math.* 11:315–20 (April).

A popular style presentation of suggestions for accurate measurements in concrete achievements and in general changes of attitude in the same sort

of standardized forms as used in arithmetic, spelling, etc. Samples of possible completion tests, association tests, and detection of absurdities tests are given.

This was originally a paper read at Minneapolis in December, 1910.

112. G. Stanley Hall. *Sci. Amer.* 104:399 (April).

A brief article, enumerating four things for which Stanley Hall stands: the recapitulation theory, the doctrine that Nature is right, catharsis, and the use of the questionnaire. While implying adverse criticism of the above, Thorndike renders tribute to the man and his motives.

113. A Scale for Measuring the Merit of English Writing. *Science* 33:935–38 (January). *Sci. Amer. Suppl.* 72:158–59 (September).

An exposition and a defence of the method of constructing a scale of relative values of English compositions on the basis of judgments. Samples are submitted, and ten further specimens for which rankings are solicited from any reader.

114. A Scale for Merit in English Writing by Young People. *J. Ed. Psy.* 2:361–68 (September).

A more detailed article than the foregoing, describing the current procedure on the Hillegas scale.

115. Psychology in Advertising. *Sci. Amer.* 105:250–51 (September).

A statement of five principles of control of mental connections, with illustrations and discussion of whether or not they are consciously used by advertisers.

116. Quantitative Investigations in Education: With Special Reference to Cooperation within This Association. *Sch. Rev. Mon.* 1:33–52.

A paper presented for discussion at the meeting of the Society of College Teachers of Education, in Mobile, Ala. It mentions the difficulties of cooperative research work, particularly in the absence of standardized units of measurement. Outlines the steps to be taken to develop scales and promote wide use of findings. Foreshadows, perhaps, the founding of the present Institute of Educational Research.

117. Review of Whipple's *Manual.* *A J. P.* 22; No. 2:307–09 (April).

A careful, scholarly analysis. He enumerates the types of tests described, commends Whipple's knowledge of the work in all fields to date, his instructions to the experimenter, his summaries and full bibliographies. He hints at a lack of balance between work involved and probable gain thereby, in one or two places, disagrees with one statistical procedure, and suggests the addition of giving the number of trials necessary to secure reliability.

118. Review of Gilbreth's *Motion Study.* *Amer. Econ. Rev.* ser. 4:1:381–82 (June).

A description of Gilbreth's book with astonishment at his lack of quotations from technical sources, and a query as to the validity of Gilbreth's general

suggestion that movement series be taught at full speed from the beginning, leaving precision for a later attainment.

119. Review of Gamble's *Study in Memorizing*. *Psy. Bull.* 8:7 (July).

Mostly a digest, but also explains the discrepancy between her results and those of Ebbinghaus and others as due to a difference in the unit of measurement.

## 1912

ANNOTATED BY ARTHUR M. JORDAN, PH.D. 1919, Professor of Education, University of North Carolina, Chapel Hill, N. C.

120. Education: A First Book. Macmillan, New York. Pp. ix+292.

The aim of Education is to change human beings for the better, so that "they will have more humane and useful wants and be more able to satisfy them." Knowledge, not utility nor even culture, is probably the most efficacious means of attaining this end. That knowledge which illumines the present and affects human behaviour in the widest possible manner is of most worth. Care must be exercised in selecting the proper material so that impersonal desires may be cultivated, and in presenting the material so that it truly stimulates the pupil to change his behaviour for the better. This aim is not attained unless we understand the fundamental impulses in human life and direct them by means of well-prepared teachers and vitalizing methods of instruction into useful habits, powers, and attitudes.

121. Professional Training for College and University Teachers. *Zeitschrift für Hochschulpädagogik* 1:5 p. (January).

122. The Curve of Work. *Psych. Rev.* 19:165–94 (May).

The author shows that the theoretical analysis of the curve of work done by Kraepelin and his followers is fallacious in nearly every point; for, if the average of the individuals' performances is taken, no initial spurt, adaptation, warming up, rise after fall, spurt, nor fatigue appears, but the curve is almost a straight line.

123. The Permanence of Interests and Their Relation to Abilities. *Pop. Sci. Mo.* 81:449–56 (November).

The interest of 100 college students, as estimated by themselves, in their subjects of instruction has remained fairly permanent ($r=.60$) in elementary school, high school, and college. Moreover, there was a high relationship ($r=.88$) between the interest shown in a subject and the success in it.

124. Handwriting. Teachers College, Columbia University, New York. Reprinted from *T. C. Record*, March 1910. Contains larger scales.

125. Introduction to Moll's *The Sexual Life of the Child*. Macmillan, New York. Pp. v–ix.

Thorndike is pleased that "a gifted physician of long experience" who is

so eminently fitted to treat of this problem should have undertaken the writing of such a book. He commends the scientific thoroughness with which the problem is treated and the frankness of it which prevents maudlin curiosity in its contents. Teachers, preachers, physicians, parents—all who have to deal with young people—will find the book helpful. Enlightenment about sex matters will be of great value in spite of the opposition due to the fear of some that it will lead to disastrous results.

126. Review of Scott's *Increasing Human Efficiency in Business*. *Amer. Econ. Rev.* 2:367–69 (June).

Scott's account of rivalry between mills is interesting and the book as a whole is a good one because it takes the scientific point of view. It is probably a little too optimistic as to the results of applying psychology to business.

127. The Measurement of Educational Products. *Sch. Rev.* 20:289–99 (May).

Measurement consists in having a series of perfectly definable facts, in making certain that each amount is a different amount of the same thing, in defining perfectly the difference between any two amounts in terms of some unit of difference, and in calculating the absolute zeros of the scale. All of these are difficult in education, but examples are given of success in some directions. The theorem that differences equally often noticed are equal is emphasized.

## 1913

ANNOTATED BY GENEVIEVE L. COY, PH.D. 1923, Director of Tests and Measurements, Shaker Heights, Cleveland, Ohio.

128. Introduction to the Theory of Mental and Social Measurement. Second edition, revised and enlarged. Teachers College, Columbia University, New York. Pp. xi+277.

Revision of one of the first books on statistics for educational workers. Procedure of finding central tendencies, variabilities, reliabilities, simple correlation, etc. Helpful practice problems. Tables as aids to computation.

129. Educational Psychology. Vol. I: The Original Nature of Man. Teachers College, Columbia University, New York. Pp. xii+327.

The following questions are answered with regard to man's equipment of instincts and capacities: To what situations does man by original nature tend to respond? What responses are made in each case? As a result of the situation-response analysis the list of instinctive tendencies varies from the traditional series. Such tendencies as "destructiveness" and "constructiveness," with their implication of purpose to make or unmake, disappear under the more exactly descriptive term "manipulation." On the other hand, tendencies such as "fear" and "fighting" are more precisely described as a series of specific responses to specific situations. Special emphasis is given to the situation-response analysis of tendencies which are most significant for education, such as responses to the approval and disapproval of other human beings; responses of

mastery and submission, vocalization, manipulation, multiform mental activity. Fallacies in the traditional discussions of imitation and play, as original tendencies, are analyzed. In a chapter on the original basis of interests and motives, the theory of readiness of neurones to act is presented as an explanation of feelings of satisfaction and dissatisfaction. A discussion of the original elements in the learning process follows, stated as the Laws of Exercise and Effect. The volume closes with a discussion of various theories concerning the appearance and disappearance of instinctive tendencies, and a brief summary of the relative value and the uses of man's original nature.

130. Educational Psychology. Vol. II: The Learning Process. Teachers College, Columbia University, New York. Pp. xi+452.

A comprehensive discussion of the psychology of improvement in mental functions. The laws of connection-forming in man are presented in two series: the primary laws of readiness, exercise and effect; and the secondary laws of multiple-response, mind-set, partial activity, analogy and associative-shifting. The importance of analysis and selection for the higher types of learning is shown in some detail. This general statement of factors involved in the learning process is followed by a detailed discussion of improvement in specific functions. The amount, rate and limits of improvements shown in practice curves is presented through the use of a large amount of experimental data, followed by a careful theoretical analysis and explanation. Factors which influence progress, such as health, interest in improvement, interest in the work, and freedom from worry and excitement, are evaluated. Experimental results on the permanence of learning are followed by a summary of the psychological conditions which are favorable to permanence. The theory of mental discipline, i.e., "the influence of improvement in one mental function upon the efficiency of other functions," is discussed in detail, with reference to all the important quantitative studies made in that field. The author concludes that transfer through identical elements, of substance, or of procedure, is the only means by which learning in one field may add to efficiency in another related field.

131. Educational Administration. (With Strayer.) Macmillan, New York. Pp. xii+391.

Reports a series of quantitative studies of problems of school administration. Data concerning pupils, teaching staff, school organization, courses of study, measurement of educational products and school finance.

132, 133. Educational Diagnosis. *Science* 37:133–42 (January); 258–59 (February).

Use of the method of correlation as a measure of correspondence between various mental traits; its use for prophesying future progress from present status. Probable prognostic value of intelligence tests, school marks, intention to remain in school, etc.

134. Ideo-motor Action. *Psych. Rev.* 20:91–106 (March).

Psychologists' rankings in order of truth of statements concerning the

general power of ideas to produce the acts which they resemble. Use of these rankings to disprove the theory of ideo-motor action.

135. Address at Teachers College Alumni Meeting. *T. C. Bull.* No. 15:5–15 (March).

Vocational guidance for school children should be given through the agency of the schools, and should be based on exact and comprehensive investigations, both of occupations and of human capacities. Teachers College should assume a due share of responsibility for the advancement of this work.

136. Improvement in a Practice Experiment under School Conditions. (With Donovan.) *A. J. P.* 24:426–28 (July).

Improvement in column addition from sixty minutes' practice, fourth grade boys. Equal additions to training have slight tendency to reduce individual differences.

137. Loeb's *The Mechanistic Conception of Life.* *Psy. Bull.* 10:331 (August).

Review of Loeb's "experimental analysis of what goes on in the development of the egg, in the growth and movements of animals," etc. Book should serve as a stimulus to the "matter-of-fact study of particulars."

138. Eugenics with Special Reference to Intellect and Character. *Pop. Sci. Mo.* 83:125–38 (August).

The relation of differences in men's intellect and character to differences in ancestry. By selection of ancestry intellect and character may be improved, and that probably without injurious by-products. Problems of discovering and perpetuating the best strains.

139. The Measurement of Achievement in Drawing. *T. C. Record* 14:5: 345–82 (November).

A scale for the merit of drawings by pupils 8 to 15 years of age, consisting of fourteen drawings, merits 0 to 17. The unit of the scale is the "difference in merit in children's drawings which 75 per cent of artists, teachers of art, and intelligent judges generally can just distinguish." Derivation of the scale. Its uses and limitations.

140. Practice in the Case of Typewriting. (With Hill and Rejall.) *Ped. Sem.* 20:516–29 (December).

Improvement in typing as result of five months' practice. Two subjects. Form of curve: steady rise, no negative acceleration. Effects of no Sunday practice and of illness. Permanence of improvement after four and a half years.

141. Theories of Mental Work and Fatigue. *Sch. Home Ed.* 33:44–47 (October).

Mechanical theory that fatigue results from depletion of a store of mental energy versus the biological theory that work without rest becomes less satisfying, by losing the "zest of novelty," by producing ennui or headaches, and by depriving the worker of desired activities.

142. The Hygiene of Mental Work. *Sch. Home Ed.* 33:84–87 (November).

Desirable methods of increasing mental efficiency, such as: improvement in general health, and in the direction and method of activity; decrease of resistances; relieving the mind from worry. "Interest for efficiency; and for protection, sleep."

143. Notes on the Significance and Use of the Hillegas Scale for Measuring the Quality of English Composition. *Engl. J.* 2:551–61 (November).

Comparison of merit of paragraph writing of high school pupils with that of "masters of English prose." A mediocre high school composition shown to represent three-fourths of possible progress in writing. Use of the scale diminishes errors in judgment of composition.

144. A Comparison of the Trustworthiness of Estimates of Yearly Butter Fat Production. *Guernsey Brdr. J.* Pp. 6.

Statistical determination of the variability and trustworthiness of annual production of butter fat, based on limited number of tests. Gives the range and frequency of various deviations of estimates from the true record. [Undertaken for the guidance of The American Guernsey Cattle Club.]

## 1914

ANNOTATED BY BESSIE L. GAMBRILL, PH.D. 1922, Assistant Professor of Education, Yale University.

145. Educational Psychology. Vol. III: Mental Work and Fatigue and Individual Differences and Their Causes. Teachers College, Columbia University, New York. Pp. x+408.

Part I defines mental work and fatigue in quantitative terms, states the problems requiring study and presents descriptions and results of typical experiments as the basis for exhaustive, critical discussion of each question. Current theories of work and fatigue are explained and evaluated in the light of available experimental evidence. A chapter on the hygiene of mental work not only utilizes relevant experimental data, but offers practical suggestions based on the hard "common sense" of a variety far from common, which is characteristic of the author's discussions of educational problems. Part II is a revision of *Educational Psychology* published in 1903 and revised in 1910. The extent, causes and measurement of individual differences are critically treated from the quantitative point of view. Experimental literature has been drawn upon liberally and selectively for description and quotation, and no important source which might affect conclusions has been ignored. As in the case of the earlier volumes there has been an attempt to present fairly the factual data on both sides of moot questions in order that the independent student may draw his own conclusions. To the advanced student of the topics treated the book is indispensable.

146. Educational Psychology, Briefer Course. Teachers College, Columbia University, New York. Pp. xii+442.

An abridged and simplified treatment of the topics covered by the three volume edition, "organized as a text-book in Educational Psychology for students in colleges and normal schools." Part I deals with the Original Nature of Man; Part II, The Psychology of Learning including the discussion of mental fatigue; Part III, Individual Differences and Their Causes. The quantitative point of view of the larger edition characterizes also this briefer course. "Its method is that of straightforward and systematic presentation of principles," but experimental data are freely introduced to illustrate the type of facts upon which the principles are based.

This book has since been translated into German, published by Bobertag.

147. Review of Wood's *Influence of Monarchs*. *J. Phil. Psy. Sci. Meth.* 11: 81–82 (January).

Commends attempt at historiometric procedure. Criticises assumption that traits studied are unit characters.

148. Some Results of Practice in Addition under School Conditions. (With Hahn and Donovan.) *J. Ed. Psy.* 5:65–84 (February).

Ninety hours of distributed practice produced marked gains in speed and accuracy; individual differences in initial ability and gains; positive relationship between initial scores and rate of gain.

149. An Experiment in Grading Problems in Algebra. *Math. Tchr.* 6:123–34 (March).

"The difficulty of certain problems in algebra as judged by the consensus of 200 teachers of mathematics." Illustrates one method of scaling test units.

150. The Measurement of Ability in Reading. Preliminary Scales and Tests. *T. C. Record* 15:207–77 (September).

Notable as marking initial discussion and presentation in preliminary form of author's scales for measuring visual vocabulary and understanding of sentences. Also early draft of Gray's oral reading scale.

151. Means of Increasing Efficiency in Arithmetic. *Indiana University Bulletin,* XII: Proceedings of a Conference on Educational Measurements: 9–25 (September).

A discussion of the psychology of arithmetic as a matter of educational engineering. The traditional view is contrasted with the application of the laws of learning to developing efficiency in fundamentals and in arithmetical reasoning. The rôle of language in arithmetical learning.

152. Tests of Silent and Oral Reading (Discussion). *Indiana University Bulletin,* XII: 37–51 (September).

Discussion following demonstration of method of giving reading tests to

children. Covers criteria for ideal test and specific questions raised by the conference, dealing with tests of comprehension, vocabulary and oral reading.

153. Individual Differences and Their Causes. *Indiana University Bulletin,* XII: Proceedings of a Conference on Educational Measurements: 59–75 (September).

An interesting presentation for a general educational audience of the facts and theories of individual differences and their causes. Experimental data are used for illustration.

154. On the Relation between Speed and Accuracy in Addition. *J. Ed. Psy.* 5:537 (October).

Further experimental evidence that the sort of student who is rapid tends also to be accurate.

155. Fatigue in a Complex Function. *Psych. Rev.* 21:402–407 (November).

Measurement of effect of four hours of continuous work at writing poetry upon quantity and quality of product and upon satisfyingness of the process.

156. Failure of Equalizing Opportunity to Reduce Individual Differences. *Science* 40:753–55 (November).

Data from experiments in mental multiplication and in addition showing by positive relationship between initial and final scores that practice fails to remove or reduce initial inequalities.

157. Teachers' Estimates of the Quality of Specimens of Handwriting. 4 supplements. 3 record sheets. *T. C. Record* 15:279–91 (November).

Description of experiments together with necessary materials to aid teachers in measuring their ability to judge the quality of handwriting and to improve their ability in this respect.

158. Some Results of the First Year's Work of the New York State Commission on Ventilation. (With six others.) *Amer. J. Pub. Hlth* 5:85–118 (December).

Tentative conclusion that high temperatures rather than breathed air are sources of physiological disturbance and of disinclination for mental or physical work. Quantity and quality of work may be unaffected by either factor.

159. Effect of Continuous Exercise and of Rest upon Difficult Mental Multiplication. *J. Ed. Psy.* 5:597–98 (December).

With two-hour work periods subjects improved in both speed and accuracy. Fatigue was measured by tests after thirty minutes' rest and after a night's rest.

160. Measurement of Ability to Solve Arithmetical Problems. *Ped. Sem.* 21: 495–503 (December).

Test results in Grades 6 to 9 used as factual basis for discussion of sex differences in arithmetical problem solving, relative educational retardation of

younger and older children in the same grade, and the procedures used in scaling test units by percentages of failures or successes of pupil reactions.

161. The Significance of the Binet Mental Ages. *Psy. Clin.* 8: 185–89 (December).

Shows unreliability of Binet mental ages 5 to 12, points out sources of weakness in Goddard's assertion of their accuracy, and on basis of data presented offers correction of the Binet values.

162. The Foundations of Educational Achievement. *Ed. Rev.* 48:487–97 (December).

An admirably clear, non-technical exposition of the reaction psychology and its implications for typical problems of method and subject matter selection.

163. Repetition Versus Recall in Memorizing Vocabularies. *J. Ed. Psy.* 5: 596–97 (December).

Brief report of crude experiment in learning vocabularies showing results slightly favorable to repetition.

## 1915

ANNOTATED BY MARGARET E. NOONAN, PH. D. 1919, Professor of Elementary Education, New York University.

164. Ideo-motor Action: A Reply to Professor Montague. *J. Phil. Psy. Sci. Meth.* 12:32–37 (January).

A defense of the author's position, as presented in *The Original Nature of Man,* that an act will not be produced by the imaging or thinking of it unless the act has in some way been previously connected with the image or act. The writer presents arguments against the position taken by Professor Montague that the denial of the ideo-motor theory implies a denial of the possibility of imitation and of perception.

165. The Disciplinary Values of Studies: A Census of Opinions. *Education* 35:278–86 (January).

An analysis of the judgments of one hundred selected teachers regarding the disciplinary values of certain school subjects and extra-school activities with the conclusion that it is better to choose school subjects on the basis of assured values in satisfying pupil needs rather than on the hypothetical grounds of disciplinary values. Evidence is presented to show that in the minds of most teachers the concept of disciplinary value of a subject is too vague to furnish guidance.

166. The Relation Between Initial Ability and Improvement in a Substitution Test. *Sch. and Soc.* 1:429–31 (March).

A study of the changes produced in the abilities of one hundred twenty college students after approximately fifty minutes' practice of the ability under

investigation, showing that the same opportunity did not level the original individual differences. The group of highest initial ability improved most per unit of time and the relative positions of the other groups remained constant in spite of practice.

167. The Form of the Curve of Practice in the Case of Addition. *A. J. P.* 26: 247–50 (April).

Six hundred seventy college students were tested in simple column addition and grouped in seventeen sections according to their initial speed. The practice curves for forty-eight column addition examples for each section and the composite growth curve for the entire group were drawn. These show the similarity of rise for all sections regardless of initial ability.

168. Means of Measuring School Achievements in Handwriting. *Ed. Adm. Sup.* 1:300–305 (May).

The study describes a simple method of sampling by which the average achievement in handwriting of a school system of one hundred thousand pupils may be measured with as satisfactory accuracy as one of one thousand. The number of samples and of judges needed for a substantially accurate measure in connection with the use of either the Ayres or the Thorndike handwriting scale is discussed.

169. Means of Measuring School Achievements in Spelling. *Ed. Adm. Sup.* 1:306–12 (May).

The article discusses the problem of constructing a test from the Buckingham list for measuring the efficiency of a school system in spelling and proper methods for both pupil sampling and test scoring. The technique suggested is less simple than has since been developed by school surveyors.

170. The Resemblance of Young Twins in Handwriting. *Amer. Nat.* 49: 377–79 (June).

This study points out the extreme rarity of perfect resemblance in the handwriting of different individuals, even twins. A method is indicated for the construction of a scale showing unintentional resemblances in handwriting that would have significance in the detection of forgery or other legal uses.

171. The Intellectual Status of Children Who Are Public Charges. (With J. L. Stenquist and M. R. Trabue.) *Arch. Psy.* No. 33. *Col. Contr. Phil. Psy.* 24:52.

The study throws light on the problem of the influence of heredity on intellectual achievement. A contrast is drawn between the intellectual status of two hundred and sixty-five children who were public charges and certain public school children who were living under normal home conditions, as shown by their abilities in the use of the Stenquist Test of Mechanical Ability, the Trabue Completion Test, the Binet-Simon Test (Goddard revision) and a reading test which measured the ability to read and comprehend the meaning of certain passages.

172. Watson's *Behavior.* (With Herrick.) *J. An. Behav.* 5:462–470 (December).

A review of Watson's book, *Behavior,* pointing out the significant contribution of the author in emphasizing the method of objective verification in presenting psychological data as opposed to uncritical observation and speculative methods. The reviewer emphasizes, however, the importance of not only the method of observation of other human beings but self-observation, which may be thoroughly scientific, and finds a place for the studies of psychologists from both the subjective and the objective angles. He considers Watson's position too extreme also with regard to "no centrally initiated processes" and "no structural modification of the neurones from birth."

173. An Improved Scale for Measuring Ability in Reading. *T. C. Record* 16:31–52 (November) and 17:40–67 (January 1916).

A revised and improved form of Scale Alpha 2 with more exact values for the different elements of the scale than the tentative ones which had been assigned a year earlier. The technique of evaluating the difficulty of the various steps of the reading scale is presented for future workers. This work constitutes the first scale to measure the understanding of sentences in which the values of the steps were determined experimentally.

## 1916

ANNOTATED BY J. L. STENQUIST, PH.D. 1923, Director, Bureau of Educational Research, Baltimore.

174. An Improved Scale for Measuring Ability in Reading (concluded). *T. C. Record* 16:40–67. [See 173, above.]

The concluding installment of an article begun in the November 1915 *Teachers College Record.* Gives method of determining difficulties of each paragraph, with sample paragraphs. This scale was the forerunner of the Thorndike-McCall Reading Tests.

175. The Technique of Combining Incomplete Judgments of the Relative Positions of *N* Facts made by *N* Judges. *J. Phil. Psy. Sci. Meth.* 12: 197–204 (April).

Gives a method of combining any number of incomplete rank-order rating for any given series to be rated, making use of indirect comparisons.

176. English Composition: 150 Specimens Arranged for Use in Psychological and Educational Experiments. Teachers College, Columbia University, New York. Pp. 127.

Each composition is rated in terms of Thorndike Extension of the Hillegas Scale (1915). Provides an excellent collection of English compositions of known value for experimental purposes.

177. Notes on Practice, Improvability and the Curve of Work. *A. J. P.* 27: 550–65 (October).

Results of an experiment in learning clerical tasks with 64 educated adults. Includes the effect of the distribution of time, of individual differences, and changes of rate in improvement; the correlation between initial ability and improvement; the effect of rests upon achievement and improvement; illustrated with curve of practice and curve of work.

178. The Significance of the Binet-Simon Tests. *Psy. Clin.* 10:121–23 (October).

Study work with J. L. Stenquist and M. R. Trabue. Four series of tests with 152 dependent children. Binet-Simon, Sentence Completion, Reading Comprehension, and a mechanical test consisting of a series of mechanisms to be put together out of loose parts. Intercorrelation shows first three to measure much the same complex of abilities. The ability measured by the mechanical test, however, is far from identical with this complex. Author submits Binet Test is not an adequate test of intellect as it neglects mechanical and executive abilities.

179. Education for Initiative and Originality. *T. C. Record* 17:405–16 (November).

Presents basic principles upon which training must be placed to make possible success in educating for initiative and originality. A stirring appeal for the development of experts in education and for placing control for educational policy in their hands. Vigorous, incisive, scintillating—Professor Thorndike at his best. Merits most careful study by every educator.

180. The Measurement of Achievement in Reading: Word Knowledge. *T. C. Record* 17:430–54 (November).

A detailed description of the Thorndike Visual Vocubulary Scale with sample of Scale A2 and Scale B, conversion tables and scoring sheets. "The obvious purpose of these scales is to measure how hard words a pupil can read . . . in the same way that a measuring tape would be used to measure how high a bar a pupil or the average of a class can jump over."

181. Tests of Aesthetic Appreciation. *J. Ed. Psy.* 7:509–22 (November).

Utilizing series of outline drawings of rectangles, crosses, border designs and a longer series of second lines in poetical couplets, this study presents an ingenious method of measuring aesthetic appreciation, of practical importance both for theoretical studies and for vocational guidance.

182. Ventilation in Relation to Mental Work. (With McCall and Chapman.) *Col. Contr. Ed.* Teachers College, Columbia University, New York. Pp. iii+83.

The report for the New York State Commission's experiment on ventilation. The aim was to discover "the effect of heat and expired air upon the quantity and quality of mental products per unit of time, and upon the readiness of individuals to work." The results were contrary to common expectation.

Individuals were urged to their best, did as much, and did it as well in hot, humid, stale and stagnant air as under optimum conditions.

183, 184. The Effects of Outside Air and Recirculated Air upon Intellectual Achievement and Improvement. (With McCall and Ruger.) *Sch. and Soc.* 3:679–84 (May); 4:260–64 (August).

May: A detailed report of experiments with 88 pupils in the sixth grade made under the direction of the New York State Commission on Ventilation. The results showed that intellectual progress was not impaired by a partial recirculation of air.

August: The report of a second experiment, practically identical with that reported in the May 6, 1916, issue. The results of this second experiment confirm the earlier findings.

## 1917

ANNOTATED BY (MRS.) LAURA CHASSELL TOOPS, PH.D. 1920. [Instructor in Psychology, Ohio State University, Columbus, until 1921.]

185. The Curve of Work and the Curve of Satisfyingness. *J. Appl. Psy.* 1: 265–67 (September).

Reports an experiment involving continuous grading of compositions, the resulting curve of work having practically zero slope but that of satisfyingness showing a sharp descent, supporting the view that the physiological effect of lack of rests is far greater in the case of satisfyingness than in that of work; also reports briefly a similar experiment, which confirms these results.

186. Early Interests: Their Permanence and Relation to Abilities. *Sch. and Soc.* 5:178–79 (February).

Reports a study employing the ranking of activities according to interest and ability therein at different periods, correlations obtained indicating that interests and abilities are rather stable and that interests are throughout symptomatic of abilities.

187. The Psychology of Thinking in the Case of Reading. *Psych. Rev.* 24: 220-34 (May).

Illustrates the usefulness for psychological study of the responses to questions upon a reading paragraph by presenting a sample task and pupils' responses to one question; reports some general facts displayed by numerous such responses, giving evidence in their support; and presents a discussion of the psychology of thinking, which notes the part played by bonds, and terminates in the conclusion that there exists no fundamental physiological contrast between fixed habits and reasoning.

188. Reading as Reasoning: A Study of Mistakes in Paragraph Reading. *J. Ed. Psy.* 8:323–32 (June).

Gives numerous responses of pupils to simple questions about a simple paragraph, presents certain facts and principles in regard to correct and incor-

rect reading as a means toward explaining the variety of the responses, and shows that reading involves typical reasoning; also explains children's difficulty with certain school subjects and false sense of adequate understanding; then applies the findings to educational theory and school practice.

189. The Understanding of Sentences: A Study of Errors in Reading. *El. Sch. J.* 18:98–114 (October).

Sketches the mistakes made by pupils in reading certain paragraphs, noting the frequency of different types; states certain facts and principles indicated by this census of errors; and presents an analysis of the process in understanding a paragraph and a discussion of the psychology of understanding, leading to the conclusion that "to read" means "to think" as truly as do the more obvious forms of reasoning.

190. Magnitude and Rate of Alleged Changes at Adolescence. *Ed. Rev.* 54: 140-47 (September).

Reports an investigation by the questionnaire method to test suppositions about certain so-called adolescent phenomena, the results of which indicate that changes are rather moderate in amount and in rate and that the maximum seems to be at eighteen; considers the investigation from various angles; then gives the conclusion that the current view regarding adolescence is largely false.

191. The Effect of Humidification of a School Room upon the Intellectual Progress of Pupils. (With Paul J. Kruse.) *Sch. and Soc.* 5:657–60 (June 2).

Reports an experiment measuring the effect of humidification upon the intellectual progress of school children through improvement in tests, the results of which show no demonstrable effect of relative humidity; notes a like result for a related experiment and for physical examinations; and states the conclusion that humidification during winter will not likely be productive of improvement.

192. Effect of Humidification of a School Room on Intellectual Progress of the Pupils. (With Paul J. Kruse.) *Mo. Weather Rev.* 45:301–02 (June).

Is a reprint of the principal part of the article annotated above, followed by a discussion of the research by the editor of the *Review*.

193. Individual Differences in Judgments of the Beauty of Simple Forms. *Psych. Rev.* 24:147–53 (March).

Reports through detailed tables measurements of esthetic preference based on rankings of the rectangles, triangles, crosses, and designs shown, in order of aesthetic merit; emphasizes the variability in preference found; and discusses some best-liked and some least-liked forms, presenting in a table the order of merit of the consensus.

194. On the Function of Visual Imagery and Its Measurement from Individual Reports. *J. Phil. Psy. Sci. Meth.* 14:381–84 (July 5).

Suggests in turn three problems in the field of visual imagery; and reports in connection with each a pertinent study, the first two of which show that the alleged best visualizers are only very slightly better in the tasks assigned than the alleged worst, and the third, that reports on ten objects will give practically as good a result as an infinite number of reports.

195, 196, 197. The Thorndike Arithmetics. Books 1 to 3. Rand McNally and Company, New York. Book 1, pp. xvi+263; Book 2, pp. xvi+286; Book 3, pp. xvi+330.

"These books apply the principles discovered by the psychology of learning, by experimental education, and by the observation of successful school practice, to the teaching of arithmetic. Consequently they differ from past practice" in a number of respects, which are stated in the preface; important among them are the following:

"Training is obtained through content that is of intrinsic value."

"The preparation given is . . . for the actual problems of life."

"Interest is secured . . . in arithmetic itself and its desirable applications."

"The formation and persistence of useful habits is not left to be a chance result of indiscriminate drill and review."

The preface, which is identical in the three books, is followed in each case by notes on the book in question, which explain certain characteristic features, and suggest more or less directly that the organization of arithmetical learning in the text be followed, since "the book," as stated in another connection, "provides for a continuous growth of arithmetical ability as an integrated whole."

Each book contains as an adjunct to the main arithmetical content (besides the preface and the notes), some tables of common measures; a table of contents, which gives under each main division the topics and activities in connection with which the learning of arithmetic is secured and, parallel with these, the main elements of the arithmetical content itself; an index; and a table of answers.

Translations of these books are proposed for South America, for Porto Rico, and for Mexico. The following appeared in 1922: Las Arithmetic Motivadas de Thorndike, Edición Castellana por Francisco Vizcarrondo y José C. Rosario, New York, Chicago. Rand McNally y Compañía.

## 1918

ANNOTATED BY PAUL F. VOELKER, PH.D. 1920, President, Olivet College, Michigan.

198. Fundamental Theorems in Judging Men. *J. Appl. Psy.* 2:67–76. (March). Also *T. C. Record* 19:3:278–88 (May).

The status of a man in the traits fitting him for a job may be expressed

thus: John Doe = 7a + 9b + 4c + 2d. A prophecy of his fitness relative to other men is obtained by attaching weights to a, b, c, d, in view of (1) their relations to fitness, (2) their partial constitution by common elements, and (3) any dependencies whereby one gains or loses in influence according to the amounts of the others which are present.

199. Individual Differences. *Psy. Bull.* 15:148–59 (May).

Humanity is a type from which each human being varies. In studying individual differences, the psychologist reduces the infinitude of tendencies of thought and action to somewhat general traits, and attempts to measure the quantity of each trait of which the individual is possessed. The "norm" for any trait is the central tendency of its distribution among a large group of individuals.

200. The Nature, Purposes, and General Methods of Measurement of Educational Products. *National Soc. Study of Ed. Yearbook* 17:2:16–24.

To measure complex educational products with precision, and to define them objectively so that competent persons may understand their magnitude, difference or relation, is a prerequisite in the task of converting education into an exact science.

201. Plan for Rating and Classification of Soldiers in the Students' Army Training Corps. War Dept., Washington, D. C. Comm. on Ed. and Special Training (November). Pp. 81.

The purpose of the plan was to select and classify officers so as to give each branch of this service the kind of men wanted, and its fair share. Each man was rated for intellect, character, physique, and athletics, command of men, and scrupulousness. The gross scores in military study and practice were secured. From these data the general officer fitness scores were determined and a line drawn between the officer and non-officer material. The gross scores in athletic-mechanical preference, the aversions, and finally the weightings of the different branches of the service were utilized in classifying men in the different branches of service.

## 1919

ANNOTATED BY FOWLER D. BROOKS, PH.D. 1921, Associate Professor of Education, Johns Hopkins University.

202. Directions for Thorndike Reading Scale, Alpha 2. *T. C. Bull.* 11th Series, No. 6. 15 (November).

Specific directions for giving and scoring the test and interpreting results; prepared by Trabue, using data by Thorndike in *Teachers College Record,* 16:415–67 (November 1915); 17:40–67 (January 1916).

203. Education for Initiative and Originality. *T. C. Bull.* 11th Series No. 4 (October). Reprinted from *T. C. Record* 17:405–16 (Nov. 1916).

204. Psychological Research for Aviators. *Science* n. s. 49:215–16 (February).

Notes omission in article by Dunlap of reference to work of Burtt, Miles, Troland, and Henmon on tests of flying ability.

205. Reading Scales: The Understanding of Sentences. Monograph and set of Scales. Out of print. To be revised as form 10 of the Thorndike-McCall Reading Scale. Teachers College, Columbia University, New York.

206. Reading Scales: Visual Vocabulary. Monograph and Set of Scales. Teachers College, Columbia University, New York.

207. Scientific Personnel Work in the Army. *Science* n. s. 49:53–61 (January 17).

Address as vice-president and chairman of Section H, Anthropology and Psychology, American Association for the Advancement of Science. Summarizes under mass work the army intelligence-testing work of Yerkes and others and the classification of personnel (involving the development of approximately one hundred trade tests), and under analytic work the more intensive, specialized, experimental investigations of Dodge, Burtt, Henmon, Stratton, Dunlap, Parsons, Thorndike, and others upon a wide variety of technical problems. "Psychology applied to complicated problems of personnel work represents scientific research of the most subtle, involved, and laborious type."

208. The Selection of Military Aviators: Mental and Moral Qualities. *U. S. Air Service* 1:14–17 (June).

Education beyond high school, attractive manners and language, frankness in replies to questions, social achievement, responsibility and leadership in life jobs, and success in school of little value in prophesying success as military aviators. Athletic and mechanical achievement, mental alertness, nerve or emotional stability, strong desire to fly, courage, determination, and endurance of positive value.

209. The Selection of Military Aviators: Physical and Psycho-Physical Qualities. *U. S. Air Service* 2:28–32 (August).

Height, weight, slight deficiencies of hearing and vision, age within limits of accepted candidates, and nystagmus (of such amounts that medical examining boards rejected men) of little significance for success. Sense of balance, delicacy of perception of tilt, nervous stability, susceptibility to "oxygen-want" in high altitudes, tests of mental alertness and of athletic interest and ability of considerable value.

210. A Standardized Group Examination of Intelligence Independent of Language. *J. Appl. Psy.* 3:13–32 (March).

Ten equivalent forms of the same general nature as Army Beta but with

less emphasis upon speed. Rigidly uniform procedure in giving the tests. High correlation with intellect as employed in managing both things and words. In addition to types of tests used in Beta, the following are included: analogies with pictures, mixed spatial-relations, memory of objects, and easy computation. Data given on practice effect, reliability, and validity. Directions may be given in any language, or language can be dispensed with.

211. Tests of Intelligence, Reliability, Significance, Susceptibility to Special Training and Adaptation to the General Nature of the Task. *Sch. and Soc.* 9:189–95 (February 15).

With wide use of tests dangers from deliberate and casual coaching increase. Five procedures suggested to avoid dangers from coaching; of these the use of alternative forms of equal difficulty is the most promising now. Greater reliability to be secured through adequate fore-exercises and longer tests. Little known of the significance of differences in intelligence (as now measured) for various sorts of achievement. Present criteria of intelligence too narrow, giving too much weight to "what can be done with a pen on paper." "A test score means only what its correlations demonstrate." Intelligence tests are faulty, but they are superior to what they displace.

212. Thorndike Extension to the Hillegas English Composition Scale. Teachers College, Columbia University, New York.

Fifteen steps ranging from quality of 0 to that of 95 are secured by dropping three specimens from the Hillegas scale and adding eight new ones. A desirable feature is the inclusion of two or more specimens of the same quality at some of the steps.

## 1920

ANNOTATED BY HERBERT A. TOOPS, PH.D. 1921, Assistant Professor of Psychology, Ohio State University.

213. A Constant Error in Psychological Ratings. *J. Appl. Psy.* 4:25–29 (March).

Attention is directed to the "halo effect" in rating, defined as "the inability of a judge to analyze out from general merit the different aspects of a man's nature and rate each in independence of the others." This is evidenced statistically by too high intercorrelations of judged traits, often out of all proportion to their true or reasonable relationships (as for instance the correlation of intelligence and physique of .51 made by an army officer using the Scott rating scale). The proposed solution is that the judge is to present only the evidences of merit, the ratings thereon to be assigned by another person.

214. Correction Formulae for Addition Tests. (With S. A. Courtis.) *T. C. Record* 21:1–24 (January).

There is often little relation between the label of a test and the ability

which plays the major part in determining the score. A formula is presented for predicting the relative interrelations of speed and accuracy in addition based on the general assumption that accuracy in addition is of itself not a measure of ability but simply a symptom of the method of work adopted. (The formula enables one to translate a performance secured at one speed or accuracy to the corresponding speed and accuracy to be expected when accuracy is taken of any predetermined standard, as, say, 70 per cent correct or 90 per cent correct.)

215. Equality in Difficulty of Alternative Intelligence Examinations. *J. Appl. Psy.* 4:283–88 (December).

A discussion of the equivalence as to difficulty of the first fifteen forms of the Columbia College intelligence tests.

216. How Fast Can You Read? How Well Can You Read? *People's Magazine* 5:33:43–47 (December). Out of print.

A popular presentation of facts known about reading ability.

217. Intelligence and Its Uses. *Harper's Magazine* 140:227–35 (January).

A popular presentation of the idea of specific intelligence, with illustrations of test material.

218. Intelligence Examinations for College Entrance. *J. Ed. Res.* 1:329–37 (May).

A discussion of the requirements of intelligence tests for college entrance, considering especially the new Columbia intelligence tests.

219. Psychological and Educational Tests. *Amer. Phys. Ed. Rev.* 25:228–33 (June).

A stenographic, unedited report of a popular informal address delivered at a convention of the American Physical Education Association.

220. Psychological Notes on the Motives for Thrift. *Annals Amer. Acad. Pol. Soc. Sci.* 87:212–18 (January).

Human nature renders man improvident rather than thrifty, since the instinct for indiscriminate hoarding of small objects cannot account for thrift. Of the two inhibitions of spending—by unreasoning repression, and by rational insight—the latter is favored, since sentiments in favor of "deferred spending" may be readily formed by pedagogical effort.

221. The New Psychological Tests: Are They a Substitute for Content Examinations? *Ed. Rev.* 59:97–104 (February).

An address before the Association of Colleges and Preparatory Schools of the Middle States and Maryland, contrasting the expected advantages of the new Columbia intelligence tests with the disadvantages of conventional college entrance content examinations.

222. The Psychology of the Half-Educated Man. *Harper's Magazine* 140: 666–70 (April).

The intelligence, trust in Lady Luck, rationalization and bad thinking of the half-educated, concluding with a plea for utilizing the services of the expert in those fields where we are restricted in our thinking by reason of the technical nature of the subject.

223. The Reliability and Significance of Tests of Intelligence. *J. Ed. Psy.* 11:284–87 (May, June).

Intelligence cannot be reliably determined with very short tests of from 20 to 50 minutes. Verbal and non-verbal tests measure different things, and a choice of these should consider that intelligence is not one thing but many.

224. The Standardization of Instruments of Instruction. *Bull. Ext. Div., Indiana Univ.* 6:14–24 (September).

A plea for standardization of instruments of instruction, with pertinent illustrations from elementary education delivered before the Seventh Conference on Educational Measurements of Indiana University. Standardization as to teaching methods is probably of less importance than standardization as to subject matter.

225. The Task of the Elementary School. *Bull. Ext. Div., Indiana Univ.* 6:4–13 (September).

A contrast of the values of the methods of educational measurements on the one hand, and of the policies of its philosophers (reformers) on the other hand—educational details *vs.* ideas about policies couched in wide, general, and often vague, terms. The method of educational measurements is illustrated by applications from arithmetic and moral behavior.

226. Thorndike Visual Vocabulary Scales: Directions for Their Use. *T. C. Bull.* 17 (February).

A test manual of administrative and scoring directions.

## 1921

ANNOTATED BY F. B. KNIGHT, PH.D. 1920, Professor of Education, University of Iowa.

227. The Teacher's Word Book. Teachers College, Columbia University, New York. Pp. vi+134.

An alphabetical list of 10,000 words which occur most frequently in the general use of language. The words were secured from forty-one different sources such as literature for children, the Bible, English classics, elementary school textbooks, vocational literature, daily newspapers and correspondence. The importance of each word is listed and credit value given on the basis of the number of times the word was found to occur. The book is very useful to a teacher in determining the difficulty and importance of words and to act

as a guide in determining what words should be taught and learned in each grade and for the improvement of teaching in general.

228. Thorndike-McCall Reading Scales for Grades 2–12. Teachers College, Columbia University, New York.

Standardized reading scales for the understanding of sentences, accurately scaled, standardized by age as well as by grade, and easy to administer. The test may be used for general survey as well as for specific teaching purposes. For specific teaching purposes the scales are so arranged that a separate one may be used for each month of the school year.

229. The Letters of William James. *Science* n. s. 53:165–67 (February).

A healthful portrayal of William James as he is revealed through his letters. The author is impressed with the fertility, receptivity to facts, theories and viewpoints of his mind.

230. On the Organization of Intellect. *Psych. Rev.* 28:141–51 (March).

An article dealing with the theory of a general factor as an explanation of positive correlations in respect to intellectual tasks. Doubt is thrown on the General Factor Theory as suggested by Spearman.

231. Intelligence and Its Measurement. *J. Ed. Psy.* 12:124–27 (March).

A review of the nature and measurement of intelligence: a contribution to a symposium. Intelligence is defined as "the power of good responses from the point of view of truth or fact."

232. The Psychology of Drill in Arithmetic: The Amount of Practice. *J. Ed. Psy.* 12:183–84 (April).

A vigorous presentation of the amount of drill on significant bonds provided by textbooks in arithmetic: the educational significance of underlearning and overlearning bonds involved in the learning of arithmetic: the necessity of careful textbook analysis.

233. Word Knowledge in the Elementary School. *T. C. Record* 22:334–70 (September).

An excellent presentation of a method in an attempt to answer the questions: how many words the eighth grade boy or girl should know the meaning of; what words should all or nearly all pupils know at that age; in what grades should the words be learned. The method explained is the basis for the construction of the famous *Teacher's Word Book*. [See reference 227, above.]

234. Measurement in Education. *T. C. Record* 22:371–79 (November).

A masterful survey of the growth of sound and exact measurement in education. Exact measurement is compared with measurement by teachers' marks. Criticisms which are being directed against exact measurement are discussed.

235. The New Methods in Arithmetic. Rand McNally and Company, New York. Pp. viii+260.

A presentation of the application of dynamic psychology and experimental education to the teaching of arithmetic from the point of view of giving the teacher or student help in understanding the newer methods and using them under ordinary conditions of classroom instruction. The material of the book is drawn from the wide and rich experience of the author. It presents in a convincing manner the method of teaching arithmetic. At the end of each chapter are arranged detailed and concrete exercises.

236. The Correlation between Interests and Abilities in College Courses. *Psych. Rev.* 28:374–76 (September).

An article dealing with the correlation between interests in a subject taken in school and the mark received in that subject and between interest rank within the individual and grade with the grade of other individuals taking the same course. The correlations were found to be low.

237. On the New Plan of Admitting Students at Columbia University. *J. Ed. Res.* 4:95–101 (September).

A presentation of the possibilities of the mental test as an entrance criterion to Columbia University. Quotations from responsible officers of the institution are freely drawn upon.

[References 195, 196, 197, were reprinted in 1921 by the State of California, as state textbooks.]

## 1922

ANNOTATED BY JAMES F. HOSIC (by proxy), PH.D. 1920, Professor of Education, Teachers College.

238. The Effect of Changed Data upon Reasoning. *J. Exp. Psy.* 5:33–38 (February).

Report of experiment with 3 groups of graduate students using 9 pairs of examples, each pair requiring identical laws but with habitual versus unusual data. Marked differences in responses reported.

239. Practice Effects in Intelligence Tests. *J. Exp. Psy.* 5:101–07 (February).

Reports amount of gain due to practice in tests similar to those in Army Alpha; proposes use of a fore-exercise to lessen such gains; finds reading tests to be almost entirely free therefrom.

240. The Abilities Involved in Algebraic Computation and in Problem Solving. *Sch. and Soc.* 15:191–93 (February).

Reports correlations between intelligence examination score and score in algebraic computation ranging from .47 to .53; between intelligence examina-

tion score and score in arithmetic problems from .51 to .70. (Article later incorporated in *The Psychology of Algebra* [1923].)

241. On Finding Equivalent Scores in Tests of Intelligence. *J. App. Psy.* 6:29–33 (March).

Considers four typical cases of measuring intelligence by different instruments and reasons for dissatisfaction with scores transmuted from one to another.

242. Instruments for Measuring the Disciplinary Value of Studies. *J. Ed. Res.* 5:269–79 (April).

Reports the devising of tests of Selective and Relational Thinking, Generalization and Organization, and symbolism for measuring improvement through the study of languages or mathematics. Two forms with a practice series available.

243. The Psychology of Labor. *Harper's Magazine* 144:799–806 (May).

Applies the knowledge of five fundamental trends of human nature to the problem of making workers happy in their work. Advocates personnel work on a scientific basis; also general improvement of conditions under which men work by utilizing laws of human behavior.

244. Changes in the Quality of the Pupils Entering High School. *Sch. Rev.* 30:355–59 (May).

Suggests modification of high school procedure because of changed personnel of student body due to increased percentage of the adolescent population attending high school, with consequent lowering of the intellectual ability of the average student.

245. The Uses of Algebra in Study and Reading. (With Ella Woodyard.) *Sch. Sci. and Math.* 22:405–15 and 514–22 (May and June).

A count of usages of algebra in high school texts and of mathematics in the *Encyclopedia Britannica.* Inferences concerning utilitarian value of topics ordinarily studied in high school. Later incorporated in the *Psychology of Algebra* [1923].

246. The Permanence of School Learning. *Sch. and Soc.* 15:625–27 (June).

Reports, as a measure of forgetting, comparative scores in a ten-minute test in algebra given graduate students and similar tests given college freshmen.

247. An Instrument for Measuring Certain Aspects of Intelligence in Relation to Growth, Practice, Fatigue, and Other Influences. *J. Exp. Psy.* 5:197–202 (June).

Offers as a test of which many forms are available, thus making repeated testing of subjects possible, the Thorndike Intelligence Examination for High School graduates. Gives figures for equating difficulty of the forms.

248. The Occupations of High School Graduates and Non-Graduates. (With P. M. Symonds.) *Sch. Rev.* 30:443–51 (June).

Reports percentages of both groups, concluding that graduates largely occupy the two or three upper levels of occupations. The correlation between amount of education and dignity of occupation is close.

249. Measurement in Education. *Nat. Soc. Study of Ed. Yearbook* 21:1–9.

A general review of the need for measurement in education, and of the kinds of instruments available. Cautions against unwise use, and answers current objections to the use of tests.

250. An Experiment in Learning an Abstract Subject. (With C. B. Upton.) *J. Ed. Psy.* 13:321–30 (September).

Reports an experiment with graduate students in 10 hours of learning a highly abstract subject. Concludes the learning of adults to be similar to that of children. Gives useful suggestions on the psychology of teaching high school subjects commonly called "hard."

251. Completion Tests in Physics. *Sch. Sci. and Math.* 22:637–47 (October).

One hundred ninety-two mutilated sentences for the correct completion of which general knowledge of physics is essential. To be grouped into tests at the discretion of the user. Contains suggestions for scoring, timing, and extending.

252. The Psychology of Arithmetic. Macmillan, New York. Pp. xvi+314.

An application to the teaching and learning of arithmetic of the principles of educational psychology. Discusses the nature of abilities in arithmetic and their measurement. Emphasizes the necessity of selecting to be formed those bonds which are useful and of arranging the teaching material as to sequence, amount, format, and phrasing to facilitate learning and drill. Suggests working with instincts rather than against them wherever feasible, and utilizing the interest intrinsic in improvement and useful knowledge. Urges attention to provision for individual differences and makes suggestions for the hygiene of learning arithmetic both as to external conditions and set of mind.

This book is being translated into Russian.

253, 254. The Nature of Algebraic Abilities. (January, February.)

255. The Psychology of the Equation. (March.)

256, 257. The Psychology of Problem Solving. (April, May.)

258. The Strength of Mental Connections Formed in Algebra. (October.)

259. The Constitution of Algebraic Abilities. (November.) *Math. Tchr.* 15; 6–15, 79–90, 127–136, 212–227, 253–264, 317–331, 405–415.

These articles were the first reports of the study of algebra made in the Institute of Research and were later incorporated in Chapters 3, 4, 5, 9 and 12

of *The Psychology of Algebra* [Macmillan, 1923. See ref. 261]. The formula, the equation and the extended number system are held to be the indispensable parts of algebra. The need for problems dealing with genuine situations for which a genuine answer is desired is pointed out. Ability to solve such and to read and construct graphs for real data is considered worth requiring. Criticism of existing texts and teaching on the basis of the inadequacy of the connections now formed leads to a consideration of what topics ordinarily taught can safely be omitted and what should be the sequence of presentation for most economical learning of those retained or substituted.

260. The Thorndike Test of Word Knowledge. Forms A, B, C, D, Bureau of Publications, Teachers College. Forms E, F, G, H printed privately.

Lists of 100 words, chosen from the collection used as a basis for the *Teacher's Word Book* [see ref. 227]. The relative difficulty, in terms of reading vocabulary of each word, is known, and the definitions, presented as choices among five words, are from terms found in the Word Book with a lesser rating.

## 1923

ANNOTATED BY BEN D. WOOD, PH.D. 1923, Director, Bureau of Collegiate Educational Research, Columbia College.

261. The Psychology of Algebra. Macmillan Company, New York. Pp. viii +483.

This compact book is mainly the result of an application to the pedagogy of algebra of the facts and principles which recent work in the psychology of learning has established. It emphasizes the dynamic aspect of the mind as a system of connections between situations and responses, treats learning as the formation of such connections or bonds, and boldly proposes the doctrine that thought and reasoning—the so-called higher intellectual powers—are not forces opposing these habits but are these habits organized to work together and selectively. A careful study of the intelligence of present high school population leads to the suggestion that more than half of the present first year students are natively unable to understand the symbolism, generalizations and proofs of algebra. A consideration of the uses of algebra leads to an indictment of the present algebra curriculum and the present methods of teaching algebra. An eloquent plea is made for the use of problems to which answers would be desired by sane persons.

Specific mention must be made of the chapter on the nature of algebraic abilities and of the group of chapters on the constitution of algebraic abilities. Of especial interest also are those on the measurement of algebraic abilities, on new types of exercises in algebra, and two chapters on the psychology of drill in algebra. The last chapter presents suggestions for further research.

262. The Influence of First Year Latin upon Range in English Vocabulary. *Sch. and Soc.* 17:82–84 (January).

A comparison of the scores made by Latin and non-Latin first year students

in 56 high schools on Forms A, B and C of the Thorndike Test of Word Knowledge, given at the beginning, middle and end of the school year, indicates that the Latins make in general over one and one-half times the gain which the non-Latins of equal initial scores make.

263. The Influence of First Year Latin upon Ability to Read English. *Sch. and Soc.* 17:165–68 (February).

Forms 2, 8 and 4 of the Thorndike-McCall Reading Scale were given to several thousand students in over a hundred different high schools at about the beginning, middle and end of a school year. The gain made by the Latins is about one and one-half times as great as the gain made by the non-Latins. The interesting fact that almost all of this gain occurred in the first half year is left to further research for an explanation.

264. The Construction and Interpretation of Correlation Tables. *J. Ed. Res.* 7:199–212 (March).

The explanation and illustration of a method of making correlation tables from given hypotheses about the causes which produce the correlation, which will give an insight into the meaning of correlation tables, diagrams and coefficients, now limited to very few experts. The prophecy is made that corrections for the effect of errors related in magnitude to the magnitude of the fact in adding skewness to distributions and bending relation lines, can probably be worked out. The fact that the self-correlation of most of the present educational measures is under 0.80 indicates that experts should try to reduce the magnitude of errors, at the outset, as well as to correct faithfully for such as remain.

265. The Diversity of High School Students' Programs. *T. C. Record* 24: 111–21 (March).

On the basis of an inventory of the school programs of the tenth grade population in ten school systems, an extraordinary diversity of curricula is set forth. In one city 529 pupils report 436 different programs. Smaller cities seem to show a similar diversity. Except for the almost universal requirements of English for two or more years and the very common requirement of algebra for the first year, high school programs have very little uniformity. The extraordinary subsidy which English receives places a great responsibility on those responsible for the teaching of English.

266. Psychology as a Life-work. Educational Psychology. *Science* 57:429–31 (April).

A brief note on educational psychology as a life-work and the requirements in terms of original ability and special training for such a career. The advantages of mathematical insight, ability to organize a mass of details, and ability to manage children in interviews and tests are emphasized.

267. The Variability of an Individual in Repetitions of the Same Task. *J. Exp. Psy.* 6:161–67 (April).

If an individual is tested repeatedly with the same mental task, the dis-

tribution of his performances is not skewed downward, when practice effects and other like factors are accounted for. This absence of excessive downward deviations from his modal performance has important bearing on the theory and practice of educational measurement.

268. The Interests of Teachers in Studies during Their High School Course. *Sch. and Soc.* 17:419–20 (April).

Retrospective ratings by advanced students of education of their relative interests in high school subject matter display great variety; every subject matter being usually put in almost every position within a group of only fifty individuals. In spite of the variety of individual interests consistent tendencies appear which are in close agreement with those reported for high school pupils in general. "Real" and "modern" content are preferred to those which are "formal" or "abstract."

269. Address in Honor of Dean Russell. *T. C. Record* 24:302–07 (May).

An affecting tribute presented for the Faculties of Teachers College to Dean Russell as a man of learning and science, a scholar and thinker. Throughout years of eminent administrative service, during which buildings and budgets, faculty and student management, direction and advice of colleagues drew him into the world of affairs, Dean Russell kept the habit of thinking, the love of ideas, the faith in truth. The felicitations and praises offered to Dean Russell are appropriately made the occasion for an ardent plea for the rights of the world of ideas and truth.

270. The Effect of First Year Latin upon Knowledge of English Words of Latin Derivation. *Sch. and Soc.* 18:260–70 (September).

An extensive application of the Carr English Vocabulary Test to Latin and non-Latin students shows that in the 25 Latin derived words, the pupils who had been studying Latin for one year made a much greater gain than the pupils who had not studied Latin, roughly, five words to two, and that in words of non-Latin origin, the Latin and the non-Latin pupils made approximately the same gain.

271. The Intelligence Scores of Colored Pupils in High Schools. *Sch. and Soc.* 18:569–70 (November).

The application of a general intelligence test to all the colored and white students in Grades 9, 10 and 11 in one city at the beginning and end of a school year shows the superiority of the white students not only by difference in average scores but by the differences in the gains of the white and colored students during the year. Less than 4 per cent of the colored pupils exceeded the median white score and the colored students gained only three-fifths as much during the year as the white pupils. In this experiment the colored pupils were not handicapped by unfamiliarity with paper and pencil tasks. The difference in the upper limits of colored and white pupils is marked.

272. Difficulty, Reliability and Grade Achievements in a Test of English Vocabulary. *T. C. Record* 24:438–45 (November).

Scores for children in Grades 4-9 inclusive on the Thorndike Tests of Word Knowledge indicate that approximately the same similarity in difficulties exists in any one section of the test as in any other. It is shown that the probable error of a determination from 40 to 80 when expressed as a number of words is not much influenced by the amount of word knowledge. The practice effect is so small for Grades 4-9 that it does not matter much how it is related to size of score.

273. The Gains Made in Ability in English by Pupils Who Study Latin and by Pupils Who Do Not. *Sch. and Soc.* 18:690 (December).

A note bearing on two reports in *School and Society,* January 20 and February 10, 1923, on the gains made by Latin and non-Latin pupils, pointing out erroneous measurements in these reports due to over-estimation of the reliability coefficients of the two tests and to under-estimation of the effect of the unreliability of the tests in combination with differences between the mean initial ability of the Latin and that of the non-Latin students. Thanks are accorded to Dr. Truman L. Kelley for pointing out that this source of error was probably larger than it was taken to be in the reports. Further study of this material is promised for later publication.

274. A Scale for Estimating the General Merit of Children's Drawings. Re-revised Edition. *T. C. Bull.* (December).

This scale is an improvement of the author's first drawing scale published in November 1913, with an account of the method of its derivation. Ratings by from five to fifteen judges on 14,000 specimens were used. The probable errors of ratings made with the help of this scale, as derived from Kelley's formula, are indicated in some detail.

275. On the Improvement in Intelligence Scores from Fourteen to Eighteen. *J. Ed. Psy.* 14:513–16 (December).

An application of a recognized group intelligence test to 3,000 pupils in Grades 9, 10 and 11, at the beginning and end of the school session, indicates a growth in intelligence equal to about ten months of Stanford-Binet mental age for each grade. In view of the fact that unselected adults average about 14 years mental age, this growth is of considerable magnitude and significance. The decrease of gain with age, if such there be, is in this case offset by the selection of those most capable of gain.

## 1924

ANNOTATED BY GRACE A. TAYLOR, PH.D. 1923, Assistant Professor of Elementary Education, University of Pittsburgh.

276, 277. Mental Discipline in High School Studies. *J. Ed. Psy.* 15:1–22 (January); 15:83–98 (February).

Difference in improvement in general intelligence due to certain studies

taken by 8,564 pupils in Grades IX-XI. Initial and final tests—I. E. R. tests of Selective and Relational Thinking, and Generalization and Organization. Sixteen tables. Data indicate small amount of general improvement, small differences between studies, and no claim to preëminence of languages. Values of studies seem to be decided largely by consideration of the special training they give.

278. The Disciplinary Value of Studies in the Opinion of Students. *T. C. Record* 25:134–43 (March).

Rankings by 78 schoolmen, familiar with present-day disputes and arguments, of studies and activities according to amount of disciplinary value to them at ages of 14-18, show extreme variety of opinion. Teaching and science ranked highest, Latin and unskilled labor lowest. Hour for hour, teaching as discipline the most valuable of the activities because of "reality." A markedly high positive correlation between disciplinary value and interest. "What one liked disciplined one's mind."

279. The Measurement of Intelligence. *Psych. Rev.* 31:219–52 (May).

Present status. Existing instruments evidence three fundamental defects: (*a*) Ambiguity in content. Need of determining actual abilities measured. (*b*) Arbitrariness in units. Need of obtaining units of mental ability which shall be at least approximately equal. (*c*) Ambiguity in significance. Need of obtaining criteria as aids in improving the selection and weighing of the elements of testing instruments. Measurement one thing, inference to intellect another.

Discussion of content and form of tests of intelligence, and of scoring, on basis of quantity and quality. Effort should be toward making the concepts of intellectual product, difficulty of producing an intellectual product, range of products produced, and speed of producing a product, more definite and precise.

280. The Influence of the Chance Imperfections of Measures. *J. Exp. Psy.* 7:225–32 (June).

Statistical study. Explanation of the general theory through illustrations. Six tables. Indicates errors and inadequacies due to neglect of this effect of the error of measurement. Suggests correlating against average of initial and final ability, rather than against initial ability, so that minus and plus distortions cancel one another.

281. The Right Use of Leisure. *J. Natl. Inst. Soc. Sci.* 9:19–26 (October).

A chief use of leisure—to restore, renew, or re-create general health and well being of body, mind, and soul. Recommendations of sleep and a good conscience for readiness to do what the world requires. Need of foresight and planning of leisure. Careful individual attention should be given to selecting activities that satisfy, gratifying human wants without interfering with others. All should live the life they can live successfully without strain.

282. The Selection of Tasks of Equal Difficulty by a Consensus of Opinion. (With Bregman and Cobb.) *J. Ed. Res.* 9:133–39 (February).

Comparison of 40 psychologists' rankings of 100 tasks selected from I. E. R. tests of Selective and Relational Thinking, and of Ability with Symbols, Trabue Completion, Thorndike Reading (unpublished), and Thorndike-McCall Reading, with their ranking by the percentages of large ninth grade groups who failed at the several tasks. Correlation of .88 indicates certain unity of meaning in minds of psychologists as to concept of difficulty. Justification for rating difficulty of tasks by opinion. Valuable in reducing labor in test construction or arrangement.

283. On the Form of Distribution of Intellect in the Ninth Grade. (With Bregman.) *J. Ed. Res.* 10:271–78 (November).

Distribution of scores made by large numbers of ninth graders in numerous cities of the United States on different tests of intelligence shows fitness to normal curve. Justification in assumption of ninth grade intelligence, if measured in truly equal units, conforming normally, and utilization of it in rating the difficulty of their intellect tasks.

284. The Vocabularies of School Pupils. *Contr. to Ed.* 1:69–76. World Book Co., Yonkers, N. Y.

Review of previous investigations on number of words known by pupils of given age or grade by Kirkpatrick, Doran, Bobbitt, Bonser, Gerlach, Brandenburg, Terman, Neher, and Holley, with summary table. Discussion of their sources and bases of selection. Comparisons with Thorndike list.

285. A Scale for General Merit of Children's Drawings. Teachers College, Columbia University. [Revision of earlier scale. See reference 139.]

Scale for merit of drawing by pupils eight to fifteen years old, consisting of seventy specimens reproduced from actual drawings of children. In pamphlet form.

286. Intelligence Examination for High School Graduates. Instructions for Giving, Scoring, and Interpreting Scores. Series 1925–1930. 11 pp. Practice form of above. 4 pp. Teachers College, Columbia University.

Three parts covering a wide range in abstract and concrete elements. Planned to differentiate among many degrees of ability. Determining factor quality of achievement rather than speed.

287. Standard Tests and Their Use. *T. C. Record* 26:93–94 (October).

Recommends that more thought be given to tests, their conclusions, and uses. Need of revisions in test elements. Advisability of informing pupils of results of their tests.

288, 289, 290. Arithmetic. Book One, Book Two, Book Three. Rand McNally and Company, Chicago. Book One, xvi+245 pp. Book Two, xvi +282 pp. Book Three, xvi+330 pp. Each book also issued in two parts.

A revision of the 1917 editions [refs. 195, 196, 197] to be in accord with the changed prices since the war.

Each book applies the principles discovered by the psychology of learning,

experimental education, and observation of successful school practice to the teaching of arithmetic. Book One is suitable for Grades II to IV inclusive; Book Two for Grades V to VI inclusive; Book Three for Grades VII to VIII inclusive. Some special features in the books are: Reasoning considered as organization and management of habits; interest in arithmetic itself should be aroused and not interest in the pictures only; linguistic difficulties, unrealizable pretenses at deductive reasoning, are omitted.

This book is being translated into Japanese.

## 1925

ANNOTATED BY ELLA WOODYARD, Research Assistant, Institute of Educational Research, Teachers College.

291. Improvement of Mental Measurements. *J. Ed. Res.* 11:1–11 (January).

Criticism of the existing instruments on the score that units are arbitrary, and that the measurements are ambiguous in significance. Suggests devising tests to measure altitude, range, facility and technique of intellect.

292. The Nature of Intellect. *Ed. Record* 6:3–12 (January).

Defends the hypothesis that the higher forms of intellectual behavior are identical with the so-called lower forms of association, requiring the same kind of physiological connections but many more of them. Gives as evidence correlations between scores in tasks in association and in reasoning.

293. On the Provision of Alternative Forms of Examinations Equal in Difficulty. *J. Appl. Psy.* 9:1–4 (March).

Calls attention to the desirability of having many equivalent forms of examination for college entrance to avoid large differences in difficulty from year to year and to enable comparisons of results. Reports method for equating scores in twelve forms of the Thorndike Intelligence Test for High School Graduates.

294. I.E.R. Intelligence Scale CAVD. Levels A to Q. Printed in 5 parts. Teachers College, Columbia University, New York.

A scale to measure intelligence as exhibited in sentence completion, arithmetic, vocabulary and directions (or paragraph reading). Useful for measuring individuals ranging from a level of 3 years to college graduates.

295. The Measurement of Intelligence. Teachers College, Columbia University, New York. (In press.)

The report of two years' study of the nature of intelligence and technique of its measurement. Emphasizes distinction in instruments for measuring the intelligence from those for measuring physical quantities in that intellectual difficulty rather than mere amount is to be discovered. Presents results of attempt to measure intellect as to its level or altitude, its width or range or area, its speed or facility. Locates a zero point of intelligence and finds

superior adults to be about twice as far from zero as average three-year-old children. Concludes area of intellect to be greatest differentiation between children and adults. Finds, however, altitude of intellect to be most significant since it is irreplaceable. Gives technique of procedure found most economical in building intelligence tests. Includes tests for levels A to Q, level A being approximately that of three-year-old children, level Q being similarly that of college graduates.

296. Inventory of Intelligence Test Items. Teachers College, Columbia University, New York. In mimeographed form for research workers.

Lists over two thousand items of sentence completion, arithmetic, vocabulary, and directions (paragraph reading) with per cents of various groups successful in them, and assigns to them a rating of difficulty as accurate as could be estimated from the data.

## Addenda

### 1914

163a. Eugenics with Special Reference to Intellect and Character. Lecture IX, in *Eugenics: Twelve University Lectures.* Pp. 319–42. Dodd Mead and Co., New York.

[Printed also as Ref. 138. Annotated under Ref. 138.]

163b. Professor Cattell's Relation to the Study of Individual Differences. In *The Psychological Researches of James McKeen Cattell. Col. Contr. Phil. Psy.* Vol. XXII, No. 4, pp. 92–101. Also *Arch. Psy.* No. 30 (April).

Reviews Professor Cattell's contributions and shows their value. Indicates the problems opened to research by the insight of this investigator.

### 1919

212a. Intelligence Examination for High School Graduates. Instructions for Giving, Scoring and Interpreting Scores. Series 1919-1924. 12pp. Practice form of above. 12pp. Teachers College, Columbia University.

Four parts covering abstract and concrete elements. Differentiates high school graduates into at least twenty degrees of ability. Tests quality of achievement more than speed.

# III. Thorndike's Contributions to Psychology and Education

## CONTRIBUTIONS TO ANIMAL PSYCHOLOGY

BY ROBERT SESSIONS WOODWORTH, PH.D. 1899
Professor of Psychology, Columbia University

ANIMAL psychology was Dr. Thorndike's first venture in the way of research. Think of him as a young man, one year out of college, beginning his second year of advanced study of psychology at Harvard. While the rest of us were setting up apparatus in the laboratory and commencing operations in the time-honored way on some experiment which might possibly come to a head later in a master's or a doctor's thesis, Thorndike, unable to obtain accommodations in the laboratory for his chosen experiment, installed an incubator in his own lodgings, and started observing the instinctive reactions of young chicks. When his landlady became worried over the fire hazard and besought him to remove his apparatus, he laid his predicament before Professor William James, who gave him space in the basement of his own home. There Thorndike continued his studies of chicks throughout the year, 1896-97, experimenting on both instinctive and learned reactions. The following autumn we find him, as Fellow in Psychology at Columbia, occupying a large undivided wing in the new Schermerhorn Hall, where he worked on the learning process in cats and dogs. The next year, at Western Reserve University, his work was in the human field; but the year after that, having returned to Columbia University as instructor in genetic psychology in Teachers College, he proceeded at once to round out his program of animal experiments by a study of monkeys. For convenience and economy of time he again used his own apartment as a laboratory. There he housed his monkeys, and labored with them for a large part of two years, ending early in 1901. Meanwhile, in the summer of 1898, he made some learning experiments on fishes at the Marine Biological Laboratory in Woods Hole.

From 1901 on, his original work has dealt exclusively with human psychology, though he has repeatedly participated in discussions growing out of the conclusions which he drew from his animal experiments, and has himself found abundant use of these conclusions as cornerstones in the edifice of his educational psychology.

It should be understood that these student performances, at Harvard and Columbia, represent a decided innovation in psychology. For the first time, they brought the animal into the field of experimental psychology. Physiological experiments on animals had been numerous, and some of them had been concerned with the senses and with reflex action. There were even some precedents for the experimental study of instinctive reactions; but there were no precedents for the experimental study of learning and intelligence in animals. The desirability and practicability of such experiments had scarcely dawned upon the mind of any psychologist. There were books on animal intelligence, ranging from the extremely uncritical and anthropomorphic to sober studies based largely on personal observation, but the whole subject was in a very unsatisfactory, unscientific condition, as had been most clearly pointed out by Wundt in the second edition of his *Lectures on Human and Animal Psychology,* published in 1892 and immediately translated into English by Creighton and Titchener. In the two lectures which Wundt devotes to animal psychology, he shows the unreliability of the anecdotal material then commonly accepted as evidence, and the pronounced anthropomorphic leaning of the biologists who attempted to utilize this material. Instead of reading into animal behavior the higher human types of mental process, Wundt urged that simpler interpretations, in terms of instinct and association, should be given the preference. This discussion by Wundt was known to Thorndike, since the book in which it occurs was used as a textbook by Professor James in an advanced general course in psychology, which Thorndike entered in the fall of 1895, at the very beginning of his graduate study. Quite possibly, then, Thorndike's first glimpse of animal psychology, as a field lying ready for scientific exploration, came from reading Wundt. The problem was not handed out to him by his professor, nor was it suggested by the Harvard zoölogists. He found his own problem, and immediately transformed it into an experimental problem, thus going beyond anything that Wundt had suggested.

In order to experiment on animal learning and intelligence, new methods had to be invented. The first device introduced by Thorn-

dike, in his study of chicks, was the *maze,* out of which the animal must find its way to reach the food box or to rejoin its fellows. The maze, simple or complex, is readily adapted to the study of learning in all sorts of animals. His second invention, utilized in the study of cats, dogs and monkeys, was the *puzzle-box,* consisting of a cage from which the animal could escape by operating a latch, hook, or other mechanical contrivance. Probably the puzzle-box was suggested by the then current anecdotes of animals opening doors and gates through imitation, it was supposed, of human beings, or through observation and reasoning on the part of the animals. Thorndike urged that the animal's mastery of such tricks could not be understood except by following the animal's process of learning the trick. He therefore placed an untrained animal in a cage with a door held shut by some form of latch—and with food outside as an incentive—and watched the animal's efforts to escape. When the animal did escape, he noted the time required, rewarded the animal with a little food, and placed him back in the cage; and continued thus, recording the time for each trial, until the animal had thoroughly mastered the trick. A third device introduced by Thorndike was the *signal* or *choice reaction* experiment: the animal must learn to do this or that, go here or there, according to the signal which is given. In all this work, Thorndike made use of the practice curve, introduced a couple of years before by Bryan and Harter in human psychology.

The experimental devices introduced by Thorndike have become the standard equipment of animal psychology, and have been employed in hundreds of studies since that day.

No less than his methods, Thorndike's results and conclusions—learning by trial and error, with "stamping in" of the pleasure-giving responses and "stamping out" of unsuccessful responses; no reasoning by animals, no imitation, no evidence of mental images or "free ideas" below the primates—immediately aroused keen interest among psychologists and biologists. The experimental method came in for severe criticism, on the ground that it placed the animal in artificial conditions and did not give him a fair chance to show his capabilities. But both methods and results have stood the test of time. None of Thorndike's observations have been discredited. Controversy has raged about the "law of effect," his interpretation of learning by trial and error; but this controversy has to do with the interpretation of results and not with the results themselves. His negative findings in respect to imitation in cats, dogs, and

monkeys were at first received with some incredulity; but these findings, with all the rest, have stood the test.

Almost immediately, on the publication of Thorndike's work, laboratories for animal psychology were started at Clark and Harvard Universities, and a little later at the Universities of Michigan and Chicago. Many others have since been established, many papers on animal psychology have been presented at psychological meetings, and special journals have appeared to provide for this large output. This great activity, which has spread in some measure to France and Germany, shows no sign of abating. On the contrary, new psychological uses for the animal experiment are even yet coming into view.

A few words are in order as to the bearing and significance of all this activity. Prior to Thorndike, the interest in animal psychology was partly a sentimental interest in animal pets, and partly an evolutionary or phylogenetic interest. Both the animal lover and the evolutionist were inclined to assimilate animal behavior as much as possible to the human,—whence the uncritical anthropomorphism of most of the earlier work. Thorndike was attracted to the field neither as an animal lover nor as a biologist, but as a psychologist, sensing the duty of psychology to explore this field, and the possibility that something might emerge of value to psychology in general. At the outset, he did, indeed, emphasize the phylogenetic bearing of his studies, for he says [1] that "the main purpose of the study of the animal mind is to learn the development of mental life down through the phylum, to trace in particular the origin of human faculty."

As his work progressed, however, he became aware of another value which the work held in store:[2]

"Never will you get a better psychological subject than a hungry cat. When the crude beginnings of this research have been improved and replaced by more ingenious and adroit experimenters, the results ought to be very valuable."

And, at the end of his animal work, the meaning of it all comes out in these strong words:[3]

"I have already hinted that we ought to turn our views of human psychology upside down. . . . When this is done we shall not only relieve human mentality from its isolation and see its real relationships with other forms; we may also come to know more about

[1] *Animal Intelligence*, 1898, p. 2. [reference 1.]
[2] *Ibid.*, p. 30.
[3] *The Mental Life of the Monkeys*, 1901, p. 57. [reference 30.]

it, may even elevate our psychologies to the explanatory level and connect mental processes with nervous activities without arousing a sneer from the logician or a grin from the neurologist."

This reads much like behaviorism, a behavorism free from the futile and needless effort to destroy the scientific standing of all psychologists who do not work on animals or by methods applicable to animals. Behaviorism, on its positive side, is an aggressive expression of a point of view that has been growing, "sub-vocally," upon the psychological world ever since the animal experiment entered the picture, a point of view that "turns our human psychology upside down," by seeking its fundamentals in processes common to man and animals, and treating what is peculiarly human as less fundamental, more derivative. The animal experiment taps the fundamentals of general psychology.

Whether, then, we measure its importance by the activity visible in the animal laboratories, or by changes in the general orientation of the science, the experimental animal psychology, inaugurated by Thorndike with such energy and good discernment, deserves to rank as one of the major developments in the history of the subject.

## CONTRIBUTIONS TO HEREDITY

BY ALBERT T. POFFENBERGER, PH.D. 1912
Associate Professor of Psychology, Columbia University

THE problems of heredity were among the earliest to be attacked by Professor Thorndike. While a student at Harvard, he undertook a laboratory investigation of instincts in chicks. From the beginning, his attitude was one of careful search for, and rigorous treatment of, facts as opposed to speculation and the expression of opinion. In discussing this earlier study he states that although chickens had been under observation by many investigators and for a number of years, he was able to discover several previously unreported instinctive responses, among them being the swimming reaction, and to note the poorly coördinated and inaccurate character of many of them. Just such data as these were needed to combat "the old theory of instinct that it was a sort of God-given power bestowed on animals to make up for their lack of reason, which in mysterious ways directed the animal's footsteps and aroused in him by direct inspiration the appropriate act in any set of circumstances,

(and that) left us an unfortunate legacy in the shape of a tendency to expect an accuracy and infallibility and unchangeableness in animals' reactions such as supernatural inspiration might well give, but which are usually signs of death in the natural world."

In discussing the instinct controversy (1899) he said: "Names are not facts, and quarrels about them are generally quarrels about rhetorical expediency. . . . There is really no need for any name and no cause for worry if we cannot invent any one definition which will consistently apply to all the facts we treat. For what is important is concrete information about particular facts." In his *Educational Psychology,* Volume I [reference 129], he asks: "How can the description of a tendency in human nature be so made as to insure that all competent students can from it identify the tendency—know what they are to look for or argue about?" In his answer and in his consequent treatment of the problem of instinct he has done much to drive away the fog of mystery that has clung about the concept. "By defining the tendency as a situation, a response and a degree of probability that, apart from training, the latter will happen when the former does." His catalog of specific situations and responses is subject to verification or criticism, item by item, by any student who is competent to observe and who has available the human material upon which to make the necessary observations.

In his review in 1906 [reference 72] of *Mental and Moral Heredity* (by F. A. Woods) he points out three shortcomings in what was a work of outstanding importance, namely, the limitation of the data on inheritance of morality to moral superiority or inferiority in comparison to the status of one period of civilization rather than absolute morality, the hasty acceptance of alternate inheritance in mental and moral qualities, and the failure to give in any convenient form the data which would permit anyone to repeat the purely statistical portion of the work by possibly better methods. "Precise objective measurements of living men and women will be our final criterion of the strength of mental inheritance."

The accumulation of just such facts has been the object of his own excursions and those of his students into the field of heredity. The first of these studies appeared in 1903 [reference 47] in collaboration with W. P. Burris, in which the school grades of about 550 pairs of siblings were compared. The coefficients of correlation ranged from $+.16$ to $+.24$ for the various school subjects. No less important than the figures themselves is the discussion of

the factors that influenced the size of the coefficients, tending generally toward attenuation.

In the same year, "The Inheritance of the Ability to Learn to Spell" [reference 47] was published in collaboration with E. L. Earle. The shortcomings of the former study inherent in the use of school grades as the measure of ability were overcome by the use of uniform spelling tests. In that one of the two schools where conditions for the study were the more favorable, the general fraternal resemblance amounted to +.51. After critical examination of the data, the authors draw the following conservative conclusion: "The results are amply sufficient to demonstrate fraternal resemblance, and in so far as this resemblance cannot be accounted for by similarities in home training, to demonstrate inheritance of the ability to learn to spell."

Thorndike's greatest contribution to the facts of mental inheritance appeared in the *Measurements of Twins,* published in 1905 [reference 61, 62]. This has served as a model for a number of similar studies. The only valid criticism raised against it in the twenty years since it was published concerns the nature of the tests used to measure ability. During this period great and significant changes have occurred in the material and technique of testing. Still the tests he employed are such as are at present in common use and form parts of practically all the group intelligence tests. Furthermore, Thorndike did not state that he was measuring intelligence, but was satisfied to compare individuals as to performance in the tests used. The coefficients of correlation between the members of fifty pairs of twins for the various tests used ranged from +.69 to +.90. His argument for the relative influence of heredity and environmental factors in the determination of these relationships is too well known to his students to justify presentation here. Taking into account the degrees of resemblance of twins of different ages, the degrees of resemblance in traits varying in susceptibility to training, and the comparison of twins with siblings in these two respects leaves no doubt that heredity is the potent factor in determining the relationship. The last paragraph of the study warrants quoting, even in this brief survey: "Special care has been taken to so arrange the material that any investigator may readily combine the measures of this research with data obtained by himself or use them for studies of individual differences, correlation, and the like; and that any critic may repeat the calculation of resemblances

after any plan that he approves. Nothing need be accepted upon my authority except the gross measures and the details of the estimation of central tendencies from which to calculate deviation measures."

The more theoretical considerations have not been neglected in the search for facts and their application to educational problems. In 1913 he opposed the views of Davenport, Goddard, and others that intelligence is transmitted as a unit character. In his opinion any system of eugenics that is based on such an assumption is doomed to disappointment and disillusionment. Human mentality cannot be improved by breeding "with the ease with which we can change short peas into tall, curly-haired guinea pigs to sleek, or plain blossoms to mottled ones" [reference 138].

The following passage out of the many that might be chosen from his writings will show that, in spite of the immensity of the problem, he views with courage and confidence the outcome of the study of heredity upon the welfare of the race:

"Surely it would be a pitiable thing if man should forever make inferior men as a by-product of passion, and deny good men life in mistaken devotion to palliative and remedial philanthropy. Ethics and religion must teach man to want the welfare of the future as well as the relief of the cripple before his eyes; and science must teach man to control his own future nature as well as the animals, plants, and physical forces amongst which he will have to live. It is a noble thing that human reason, bred of a myriad unreasoned happenings, and driven forth into life by whips made aeons ago with no thought of man's higher wants, can yet turn back to understand man's birth, survey his journey, chart and steer his future course, and free him from barriers without and defects within. Until the last removable impediment in man's own nature dies childless, human reason will not rest."

## CONTRIBUTIONS TO THE LAWS OF LEARNING

BY PETER SANDIFORD, PH.D. 1910
Professor of Education, University of Toronto

THOSE of us whose professional training dates back to the pre-Thorndike era remember well the laws of learning which were dinned incessantly in our ears. "Proceed from the simple to the complex." "Start with the concrete and end in the abstract." "Proceed from the empirical to the rational." "Create a pleasur-

able excitement in the pupils." "The genesis of knowledge in the individual must follow the same course as the genesis of knowledge in the race." "In education the process of self-development should be encouraged to the fullest extent."

Dear old Pestalozzi! Dear old Spencer! Yet though we smile patronizingly upon them to-day, they in their time played their parts and played them well. If it were not for the scientific scepticism of a Thorndike we should still be dictating their laws as the last words in educational wisdom. Perhaps the next generation will smile pityingly upon us, and, for the sake of educational progress, we hope that they will. Yet we cannot but believe that we are on more solid ground than were our forebears.

That Thorndike was not the first writer to criticize the general lack of precision in the statements of older writers is easy to prove. Bain, the Aberdonian Professor of Logic, in his *Education as a Science,* deals many a shrewd blow at the inadequacy of some of their statements. In discussing the law "proceed from the known to the unknown" Bain admits the wisdom of the principle but shows how liable to uncertainty it is in its application. I suspect from a re-reading of Bain, which was assigned as a reference in my Teachers College days, that Thorndike must have been somewhat influenced by the Scotch philosopher. Some of the chief studies of Thorndike—individual differences, handwriting, instincts—are foreshadowed in the earlier work. It needs no great effort of imagination to picture a younger Thorndike than we know pondering over the "uncertainty in application" of many other educational laws which most of us accepted quite uncritically. And while Bain was content to state, "All pupils should be brought up to the point of plain passable writing; . . . it is not the schoolmaster's business to carry writing to the pitch of a work of art," Thorndike later determined objectively what "plain passable writing" should be. I may be mistaken, but the following excerpt from Bain seems to exhibit quite a Thorndikean touch. "Much of the curiosity of children, and of others beside children, is a spurious article. Frequently it is a mere display of egotism, the delight in giving trouble, in being pandered to and served. Questions are put, not from the desire of rational information, but from the love of excitement." Thorndike in one of his lectures to us said: "Children don't usually ask questions because they want to know, but to get talk back."

Thorndike's laws of learning can be traced back to his studies of

animal intelligence and learning, published between 1898 and 1901 [references 1, 3, 14, 30]. At this time books dealing with the sagacity of animals, never with their stupidity, were very numerous. People at large thought animals very much more intelligent than they have since proved to be. Even such eminent scientists as Romanes and Lloyd Morgan had attributed to animals a degree of intelligence and a power of imitation (even of judgment and reasoning) which was quite misleading. Thorndike in a series of ingenious experiments put the subject of animal learning to crucial test. He showed that the results obtained could be explained without dragging in the hypothetical powers of imitation, judgment and reasoning. He entitled us to say of writers of animal stories in general what the Earl in "The Admirable Crichton" said of them after his ineffectual attempts to get the monkeys to throw cocoanuts down to him—"The liars!"

The first law to emerge was the law of effect. Thorndike, it will be remembered, in his early animal experiments used original satisfiers such as food to the hungry cat, company to the lonely chicken, as rewards for certain actions. He took the law for granted as so many before him had done. Gradually, however, it became one of his most important principles of education. In his *Educational Psychology,* 1903, p. 103 [reference 46] we learn that "the work of education is to make the outcome of desirable activities pleasurable and to inhibit their opposites by discomfort." In *Elements of Psychology,* 1905, p. 203 [reference 59] the principle is explicitly stated in the law of habit-formation. "Any mental state or act which in a given situation produces satisfaction becomes associated with that situation, so that when the situation recurs the act is more likely than before to recur also." And conversely for discomfort. The educational applications are found in *Principles of Teaching,* 1906, p. 110 [reference 65]. "Put together what you wish to have go together. Reward good impulses. Conversely; keep apart what you wish to have separate. Let undesirable impulses bring discomfort." When *Animal Intelligence* appeared in 1911 [reference 107], p. 244, the law was called the "law of effect" and as such was embodied, with slightly altered wording, in the three-volume *Educational Psychology* of 1913 [references 129, 130, 131].

The "law of exercise" also appeared in *Animal Intelligence* with a supplementary one designated the "law of instinct." In the later *Educational Psychology* the law of instinct is replaced by the "law of

readiness," so now the laws of learning according to Thorndike may be said to be (1) the law of readiness; (2) the law of exercise which comprises the laws of use and disuse; and (3) the law of effect. Subsidiary to these main laws are the laws of (*a*) multiple-response or varied reaction; (*b*) attitudes, dispositions, preadjustments or "sets"; (*c*) partial or piecemeal activity of a situation; and (*d*) associative shifting. These four subsidiary laws or principles, like the three major laws, grew out of the experiments in animal learning.

The law of effect is discussed at great length by Thorndike not only in his numerous books, but also in his still more numerous articles. He takes great pains to show that use alone is inadequate to explain learning. Practice does not make perfect if the resultants of the practice are painful. Nobody achieves perfection in sitting on a pin or poking a fire with the finger, yet much of the literature on habit formation would lead one to suppose that one would. He lists samples of original satisfiers or instinctive likes, and of original annoyers or instinctive aversions. So far as I am aware he nowhere states his belief that these may be explained quite satisfactorily by the theory of evolution. What was painful in the first instance was that which was harmful; what was pleasant was that which was conducive to survival. These, surely, are the "independent satisfiers and annoyers." An animal must avoid the extremes of heat and cold, that is, these must be painful to the animal if it is to survive. The animals that felt no discomfort in icy surroundings or in scalding water have vanished from the earth; those that did, and adjusted themselves accordingly, survived. The whole gamut of satisfiers and annoyers from sex to starvation can be explained in this way. It is no accident of nature that protopathic sensitivity is more ancient in origin than epicritic. The fact that satisfiers and annoyers become associated with the central nervous system (see *Animal Intelligence* and *Educational Psychology*) is not to be wondered at; it is just what is to be expected. Thorndike, of course, is not unaware of this but somehow fails to state it. Such a passage as the following is mystifying unless the evolutionary hypothesis is accepted: "Satisfaction and discomfort, welcoming and avoiding, thus seem to be related to the maintenance and hindrance of the life processes of the neurones rather than of the animal as a whole, and to temporary rather than permanent maintenance and hindrance." (*Animal Intelligence,* p. 246.)

Throughout the whole of Thorndike's work on learning the words,

situation, bond and response, symbolized in S–→R, occur. They are not rigidly defined but no one doubts that he uses them as the behaviorists (Watson, for example) use them. The behaviorist uses stimulus as it is used in physiology, as a relatively simple factor (e.g., light waves of different length) influencing the responses of organisms. When these factors are more complex (as in the environment of a social world) they are called situations. Situations, therefore, are the total mass of stimulating factors which lead organisms, including man, to react as a whole. Response is similarly to be understood. The response may be simple or complex. If it is complex a better word to use would be reaction, but response is now general for both. Bond or connection is to be regarded as having its physical basis in the central nervous system. The whole of the law of the prophets regarding learning is summed up in S→R.

In the province of learning Thorndike has shown where confusion of thought most frequently exists—in zero accomplishments and in physiological limits. Yet in spite of his writings, there is still more confusion in these fields than in any other. Especially is the problem of physiological limits of learning in an unsatisfactory state. Should not the argument run somewhat as follows? Physiological limits are due to hereditary equipment. This varies not only with species but with individuals within the species. The hereditary powers of a human being are fixed at the moment that fertilization of the ovum occurs. From that time on no further powers can be added, although, through environment, they can be destroyed or allowed to remain dormant. Environment in the form of food, use, education, etc., develops or stimulates potential hereditary powers. A theoretically perfect environment, which, of course, implies a perfect education, would develop to the physiological limits all the inherent powers, traits and capacities. A human creature so developed would not be socially perfect, because the socially bad as well as the socially good would be developed; but he would be naturally and organically perfect. But environment is never perfect and so achievement is generally (always except for comparatively unimportant functions) on lower levels than nature's potentialities. Environmental stimuli develop, but never to the limits; and the gap between the practical and the physiological or hereditary limits is a measure of the failure of environmental training. These gaps, as experiments show, are usually enormous. Education, in this sense, is the greatest failure known to man.

For learning, the hereditary equipment of the central nervous system with its billions of neurones connected with millions of muscle and gland cells is the important fact. Such an equipment in any average human being would lead one to suppose that he could, given sufficient time, learn anything. But though, theoretically, every neurone can be connected to every other neurone and to every muscle and gland cell, in practice we find hereditary and habitual patterns standing in the way. Everybody is limited in learning not only by his general inheritance but by his previous learning. For these reasons the theoretical limits are practically never reached. Further, the very multitude of possible connections precludes the reaching of hereditary limits for anything but the simplest of functions.

If we do not posit theoretical limits to improvement in mental functions we must subscribe to the doctrine that given sufficient time and zeal anybody can learn anything. But all known facts are against the doctrine. Limits exist for each particular function of each particular individual just as surely as the limit of speed, say, of nine seconds for the hundred yards' sprint race, exists for man in general. The nervous, muscular and glandular system of man is wonderfully plastic, but it has its limitations. Interest and zeal will accomplish apparent miracles in the improvement of complex functions, but there is always the gap, narrowing with each effort, which cannot be bridged, and chiefly because of the law of diminishing returns in the realm of learning.

In no field has Thorndike's genius shone so brightly as in that concerned with formal or general discipline—the influence of improvement in one mental function upon the efficiency of other functions. The state of educational thought on the subject at the beginning of the century was well illustrated by the quotations he gave in his first *Educational Psychology,* 1903, pp. 82-84 [reference 46]. No wonder that his researches, with Woodworth, on the "Influence of Improvement in One Mental Function upon the Efficiency of Other Functions" [reference 39] proved such a bombshell. The tradition of ages was challenged. After a great number of experiments upon the result of training in estimating areas, lengths, and in various forms of observation or perception upon slightly different forms, these investigators concluded that:

"Improvement in any single mental function need not improve the ability in functions commonly called by the same name. It may injure it,

"Improvement in any single mental function rarely brings about equal improvement in any other function, no matter how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case."

The educational world was immediately up in arms. Scores of experiments were designed to confirm or refute these findings. On the whole, Thorndike's position was maintained and accepted, although identity of ideal was added by Bagley. The three generally accepted identities became those of matter, method, and aim. But Thorndike had given the doctrine of formal training its death blow. There might be general discipline, but it was certainly much less than was supposed. It was advisable, on the whole, to train the mental function directly rather than to trust to indirect methods. How this led to the controversy between Spearman and Thorndike about general and specific intelligences, it is not my task to trace. Suffice it to say that after Spearman seemed to have won the day, Thomson and Garnett showed that Spearman's case was "not proven." Opinion then swung over to Thorndike's side and there it remains to-day.

Thorndike, however, has recently returned to the problem and in his paper "Mental Discipline in High School Studies" [references 276, 277] has thrown new light on it. The paper is highly technical, but his conclusions are not. For high school students, the order of studies having the greatest influence upon the gain made during the year in power to think, or intellect, or whatever our stock intelligence tests measure is: (1) arithmetic and bookkeeping; (2) physical science; (3) algebra and geometry; (4) Latin and French; (5) physical training; (6) civics, economics, psychology and sociology; (7) history, music, shop, Spanish, English, drawing and business; (8) dramatic art, cooking, sewing and stenography; (9) biological sciences. But the amounts are so small as to be almost negligible. And then he surprises the reader by this final illuminating paragraph —one of the best he has ever written:

"By any reasonable interpretation of the results, the intellectual values of studies should be determined largely by the special information, habits, interests, attitudes, and ideals which they demonstrably produce. The expectation of any large differences in general improvement of the mind from one study rather than another seems doomed to disappointment. The chief reason why good thinkers seem superficially to have been made such by having taken certain

school studies, is that good thinkers have taken such studies becoming better by the inherent tendency of the good to gain more than the poor from any study. When the good thinkers studied Greek and Latin, these studies seemed to make good thinking. Now that the good thinkers study Physics and Trigonometry, these seem to make good thinkers. If the abler pupils should all study Physical Education and Dramatic Art, these subjects would seem to make good thinkers. These were, indeed, a large fraction of the program of studies for the best thinkers the world has produced, the Athenian Greeks. After positive correlation of gain with initial ability is allowed for, the balance in favor of any study is certainly not large. Disciplinary values may be real and deserve weight in the curriculum, but the weights should be reasonable."

The writer was specially pleased to meet with the above because it supported a concept of intelligence which he had been defending in his classes for a number of years, namely, that intelligence is a function of the central nervous system. If a nervous system integrates easily and tenaciously, it is the nervous system of an intelligent person. If, on the other hand, a nervous system integrates with difficulty and loses its integrations easily, it is the nervous system of a stupid person.

But, sad to say, in spite of the work of Thorndike and others on the problem of general discipline, and in spite of a general agreement on the subject among scientific workers, the actual work in the schools is still based on the false doctrine. It is an illuminating example of the slowness with which the great mass of the public absorbs new ideas. Still, as J. L. Paton, late Highmaster of the Manchester Grammar School, used to say: "Patience and perseverance will put a polish on a blanket; *ergo* stick to it."

In the limits allotted for this article there is no space to discuss any other aspect of the problem. Thorndike spills ideas and suggestions at every turn and a whole volume would fail to do him justice. The writer would have liked especially to deal with Thorndike's contribution to the problem of interest and discipline where he shows that "the discipline from enduring the disagreeable seems to be far outweighted by the discipline from working with an interested will along lines that fit one's abilities." In trying to illustrate the importance of Thorndike's contribution in the special field of learning, the writer is acutely conscious that the task has not fitted his abilities. He hopes, however, that he has been disciplined, for

he has worked with an interested will inspired by sincere respect and affection. And with sincere respect and affection this tribute is laid before his former teacher.

## CONTRIBUTIONS TO CHILD PSYCHOLOGY

BY LETA S. HOLLINGWORTH, PH.D. 1916
Associate Professor of Education, Teachers College

PROFESSOR THORNDIKE'S contributions to child study, as distinct from his investigation of other matters by means of children, appear chiefly in reviews, in comments written to introduce the work of others, and in lectures. In these discussions his interest is always dual—scientific and humanitarian. We must experiment with children in order to ascertain the facts about them; but also in order to promote the happiness and good of the child. "As a means to general welfare and also for its own sake, a child's mental health needs care."

Before the opening years of the twentieth century, the methods of child study had been very inadequately questioned. In Professor Thorndike we find a competent cross-examiner, bringing out again and again the fallacies of current methods, and exposing uncritical reliance upon the anecdotes of the uninformed. In his reviews of Hall [references 4, 5, and 53], Major [reference 86], King [reference 57], and Kirkpatrick [reference 56] there is steady insistence upon the value of direct experiment, as compared with the futility of retrospection, parents' recital, and uncontrolled observation. In place of these he urges from the first "A set of experiments on children from birth on, in circumstances where their experience of and instruction about things could be regulated and its influence as a disturbing factor completely known" [reference 4].

The *Notes on Child Study* [reference 37], appearing first in 1901, had developed by 1910 into the book entitled *Educational Psychology* [reference 106]. In this work the boundaries of knowledge about exceptional children are defined, the state of ignorance in the subject is made clear, and the direction of subsequent researches is forecast.

*The Original Nature of Man* [reference 129] must certainly be considered as belonging to the field of child study. It bears on its face evidence of its source in the direct scrutiny of children. It effects a synthesis of what has been learned from the subhuman

animals, particularly the primates, and from the human young, by one who has known them both at first hand.

In 1915, with two of his students, Professor Thorndike published "The Intellectual Status of Children Who Are Public Charges" [reference 171]. This monograph revealed what all need to know, who deal with foundlings, dependent orphans, adoptive parents, or who are otherwise philanthropically concerned with children. Dependent children are, as a group, selected for unfortunate mental equipment. Their limitations are, on the whole, more marked than those of children in general. These conditions obviously have widespread and immediate applicability to the education and social adjustment of juvenile dependents.

In fact a large number of the experimental investigations summarized elsewhere in this volume might well be discussed as child study, since they have so often dealt with children as subjects. However, for the present purpose these researches are more properly considered under other categories. In conclusion, it may be said that Professor Thorndike has influenced child study at first by critical reproach of fallacious methods and of sentimental attitudes, and by his stimulating statements of problems awaiting research, many of which have engaged his students; and later by actual investigation to determine the qualities and characteristics of children. In *The Original Nature of Man,* above all, his direct study of the human young comes to living, moving expression.

## CONTRIBUTIONS TO INDIVIDUAL DIFFERENCES

BY AUGUSTA F. BRONNER, PH.D. 1914
Assistant Director, Judge Baker Foundation, Boston

ALREADY in his earlier writings we find the theme of individual differences clearly enunciated by Thorndike, and it is a fascinating study to trace its reappearance again and again, in his subsequent writings, to follow his ever-clearer emphasis of the import of the theme, the richness of the proof offered, the vision of the future's possibilities in both experimentation and practical uses.

As early as 1902, group differences were being investigated by Professor Thorndike to determine from actual data whether popularly held differences really existed. The study, "Marriage Among Eminent Men" [reference 42], based on data from *Who's Who,*

not only proved the fallacy of the unscientifically founded belief that eminent men marry late, but also showed the possibility of utilizing for experimental investigations data gathered originally for entirely different purposes.

Analogously, the study, "The Careers of Scholarly Men in America," 1903 [reference 45] showed from college alumni records occupational differences existing at various time periods, and the popular article, "Sex in Education," 1906 [reference 66] stressed the generalization that certain educational practices based on supposedly existing sex differences have indeed no such basis, the truth being that "schools fail . . . . to fit their work to individual differences apart from sex."

It was soon after this, in 1905 and 1906, that in his textbooks, *Elements of Psychology* and *Principles of Teaching* [references 59 and 65], Thorndike presented clearly and forcibly his point of view concerning the existence and practical importance of vast individual differences. "Nature does not provide each human being with the same capital of instincts and capacities." In detail, individuals vary in respect to (1) intensity of certain desires and interests, (2) capacity for connecting acts with mental states speedily, surely, and permanently, (3) capacity for attending to abstract considerations, (4) capacities for resisting the strain of effort, and (5) other functions which influence human action. The small book entitled, *Individuality* [reference 108], published in 1911, covers in truly masterly fashion a discussion of the nature of individual differences, their causes, and their significance. An article published soon after this confirms a generalization earlier made, namely, that equalizing opportunity does not reduce individual differences. [*Science* 1914: reference 156.]

In 1914, in Thorndike's *Educational Psychology* [reference 145] there is even a more interesting presentation of the subject, more interesting because more elaborated, and containing a digest of a number of experimental studies bearing on various aspects of the general topic. Many of the studies carried on by Thorndike himself during the previous years offered data, for while the solution of other problems was being sought, each research also brought added proof of the facts of deviations from established norms or central tendencies.

With the experience of psychological work in the Army came renewed proof of the practical significance of individual differences.

Wartime needs served as a tremendously strong impetus to ingenuity in devising means of discovering varied capacities, not only regarding general intelligence but also of highly specialized abilities, and offered convincing proof of the feasibility of such discovery and of the practicability and value of utilizing revealed individual differences.

During this period of our country's great need, Thorndike brought to bear that which has always distinguished him, the ability to apply experimental methods in original and convincing ways, and the vision to see the significance of the results of experimentation. Speaking of the army findings, he says that if one put together the contributions made, "the total probably would be the greatest increase in scientific control over the management of men ever made in any year in any country."

And out of this experience we find Thorndike from this time on stating and restating the general thesis: "Individual differences are the rule." Now appears the clear conception that too greatly have been emphasized differences in abilities to deal with words and abstract ideas, and that practically of equal importance is recognition of individual differences in abilities to deal with materials and mechanisms; and somewhat later there is added to this the third sub-theme —variations in ability to deal with people and passions. Critical always, willing to destroy in order to build better, Thorndike frankly states [reference 207] that it may well be "our procedure in measuring intelligence requires critical review and probably the common view of intelligence requires reconstruction." But along with this criticism appears the vision of possibilities for better and wider application in the future—in this case, the possibility of finding individual differences in the population, or parts of it, in times of peace, with the encouraging statement that to gain, for example, such knowledge of all the ten-year-olds would entail no greater cost than did five hours of war to the United States.

A brief report in 1919 [reference 210] indicated Thorndike's interest in the possibility of determining, by means of group tests, and secondarily, by non-verbal tests, differences between groups. Such an attempt showed the feasibility of discovering differences between the feebleminded, sixth grade pupils, high school students, superior adults. But from the war period to the present (though doubtless in other experimental work new data have been gleaned), his contribution in the more strictly limited field of individual differences has been to give ever more pointed enunciation of his general

thesis: "The facts of everyday life, when inspected critically, indicate that a man has not some one amount of one kind of intelligence, but varying amounts of different intelligences." "No man is equally intelligent for all sorts of problems. There is a general rough correspondence or correlation, such that a man mentally intelligent in one respect will usually be above the average in others also. But the correlation is far from perfect." [reference 217.]

The belief in individual differences having become widely accepted and the use of psychological tests to estimate these differences having been generally adopted, the next necessary stage in advance to greater accuracy and truth has been formulated for us by Thorndike. In the articles appearing in the *Psychological Review,* 1924 [reference 279], there appears a clear statement of the defects and weaknesses of psychological tests now in use, of the need for critical evaluation, not only of tests, but also of test findings. Professor Thorndike wisely tells us that the instruments of measurement need improvement, that norms require revision, that "unreliabilities must be ironed out by vigorous experimentation." Forcefully it is pointed out that as yet no sound criteria of intelligence exist, that what is measured is often unknown, as well as the significance of the findings.

Appreciating the truth of these criticisms, we are grateful for a formula given us by Thorndike in 1919: "To obtain an individual's true status in comparison with other individuals on a standard test of intelligence, after the pattern of the Stanford-Binet or Army Alpha, requires thirty minutes fore-exercise, two hundred minutes of tests, the test material being chosen from an extended array of alternative forms of equal, or at least of defined, difficulty" [reference 211]. Probably to-day he would add to this prescription somewhat similar directions for determining abilities in mechanical pursuits and, were it possible, in social aptitudes.

Just as it would be well-nigh impossible to select from among all works of art, the *most* beautiful, so it is quite impossible to state Thorndike's greatest contribution. But it is safe to say that his repeated emphasis of the general fact of individual differences is one of the most valuable scientific principles he has stressed, especially in view of the importance of practical applications. The present trend among progressive thinkers towards recognition in all fields of human endeavor of the principles of individualization receives scientific support and justification from his own experiments and his deductions from the works of others.

Our greatest debt to him is due to the fact that although always critical, he is always constructive; while showing the weakness of the old, he presents the better findings of the new. He himself exemplifies in extraordinary degree the standard formulated by him: "One can only learn the facts, interpret them with as little bias as possible, and try to secure more facts."

# CONTRIBUTIONS TO THE PSYCHOLOGY OF INTELLIGENCE

BY JOHN P. HERRING, PH.D. 1924
Associate in Research, Institute of Child Welfare Research,
Teachers College, Columbia University

## OBJECTIVES

THORNDIKE has himself stated objectives for his work. Five years after he received his doctorate, he suggested [reference 46] investigations of problems in educational science, of which the following relate to the psychology of intelligence:

Construction of intelligence examinations.
Units of mental measurement.
The distribution of mental traits.
Interrelationships of mental traits.
Original and acquired traits.
Mental growth.

In 1906 [reference 69] he complained of the inadequacy of college entrance examinations. In 1914[1] he said that the most important work in individual psychology was the testing of the tests. In 1921 in the symposium on the nature of intelligence, he suggested the following next steps in research:

An analysis of the intellectual work of the world in its chief types, by means of total and partial intercorrelations.
A similar analytical study of intellect.
A study of large numbers of intercorrelations relating the several abilities of man and his intellectual tasks in the world.
A study of the intercorrelations of each test at each chronological age with itself at later ages, and with each feature of intellectual work.
The determination of the form of distribution of intelligence among adults.
The determination of the effects of coaching, both specific and general.

In 1924 [reference 279] he asserted three ambiguities in our best

[1] *Psychological Researches of James McKeen Cattell*, p. 63. [ref. 163b]

intelligence tests,—of content, of units, and of meaning. He said it should be discovered:

What our present tests measure.
How our present tests are related to intellect.
What abilities constitute intellect.
How our present tests measure intellect.

He further suggested experimentation with new tasks which are promising as symptoms of intellect. In 1925 [reference 291] he says that the chief need now is to improve the truthfulness and the precision of our measures.

### CRITERIA FOR INTELLIGENCE EXAMINATIONS

With these objectives all held implicitly perhaps as early as 1898 [reference 1] and developed throughout subsequent time, Thorndike created a variety of instruments of precision for the study of animal and of human intellects,—instruments which have naturally been more fully educed in the case of human measurement. Thus, while higher animals measuring lower may perhaps never reach those degrees of completeness and exactness to be expected of a species measuring its members, man, in observing the effectiveness of his own connection system (the mind), has gone so far as to give specific attention to criteria for the construction of intelligence tests.

In 1904 [reference 52] Thorndike listed and defined these criteria:

Validity.
Homogeneity of content.
Identifiability of facts and differences.
Comparability of facts to be measured.
Identification of defined zero.
Identification of absolute zero.

In 1919 [reference 211] he further listed and defined criteria intended to guarantee the constancy of measures:

Secrecy.
Existence of alternative forms of examinations, the best guarantee of constancy.
Resistance to coaching.
Use of questions in which the effects of practice and coaching correlate with intelligence.

He gave emphasis to the importance of reliability by writing articles about it and by invariably measuring it in his tests [references 223, 218]. In 1908, he wrote concerning the effect of practice in a purely

intellectual function [reference 83] and in 1922 [reference 239] concerning means for the control of the effect of practice in taking examinations. In 1924 [reference 279], viewing intellect as of three dimensions, depth, breadth, and time, he stated the implications that instruments for measuring intelligence must yield numbers, plus or minus other numbers, representing separately the status of the individual as to the highest level of difficulty of tasks he can do, his status as to the number of tasks he can do at each level, and his status as to the number of tasks he can do per unit of time at each level. These also are criteria for making and judging intelligence examinations. Of them, the first, depth or level, is both the irreplaceable attribute and the indispensable measure—for it differentiates our Aristotles, our average men, and our idiots. To produce one genius is worth more than to prevent the birth of ten thousand imbeciles.

### INTELLIGENCE EXAMINATIONS

Criteria for judging the *pragmata* and *agenda* of human experience are not only saprophytic upon the decaying stems of other forms, but also symbiotic growths in the relation of reciprocal dependence. Coming out of experiences with examinations, they also influence the growth from which they came. Thorndike has himself described the following of his intelligence examinations:

A Standardized Group Examination of Intelligence Independent of Language. [reference 210]

The Thorndike Intelligence Examination for High School Graduates. [references 218, 221, 237, 241, 247, 286, 293]

The I. E. R. Tests of Selective Thinking, Generalization and Organization. [reference 242]

The I. E. R. Intelligence Scale, C A V D, he will doubtless soon describe.

The Thorndike intelligence examinations of various types are perhaps unsurpassed, in some respects and as a whole, by any similar number of group examinations of intelligence from the hand of any author or group of authors. None of them was completed without sagacious, diligent attempts to make it measure what it purported to measure. None was issued without interpretable, numerical statements of coefficients of validity and of probable error [reference 223]. The examinations have had the rare luxury of enough forms of predetermined, measured equivalence not only among themselves, but also with such as the Alpha and the Binet and hence mediately

with many others. The range has extended above and below the levels of measure with known, sufficient margin. The effect of practice has not only been always merely of record, but also interpretably so, and with specific reference to level. Fore-exercises, keys for scoring, measures of working time and of administration time, and descriptions of content have issued contemporaneously with the tests. Knowledge of detail has been published in articles as soon as the instruments themselves have become available.

### OUTCOMES IN PURE PSYCHOLOGY

This instrumentation has, as one chief outcome, progress in the solution of problems intimately related with the organization of intellect. The point of view seen in exposition and method seems in a general sense consistent with the hypotheses of evolution, pragmatism [references 1, 46], mechanism, and behaviorism, and inconsistent with the hypotheses of introspectionism [reference 41].

### DESTRUCTIVE OUTCOME

This progress involved first the destruction of existing theory. Neither lower animal nor human intellect is organized in faculties [references 1, 28, 41, 46, 162] or with any transfer [reference 39] in the absence of common elements of fact or of attitude; or by ideas causing action [reference 134] apart from the effects of previous success and failure; or by native imitation [references 1 and 46]. Intellect is not thus organized.

A more formidable and more recent theory of the organization of intellect was that of Spearman, who in 1904[1] proposed a hypothesis of general intelligence and in 1912[2] its now famous but refuted criterion of correlations between certain columns of correlations. This Thorndike resisted by considerations, in 1903, of functional complexity [reference 46]; in 1909 of fine specialization of functions with respect to content [reference 91]; in 1909 and in 1916, of low and zero correlations between abilities [references 92, 177]; in 1921, of failure of special training to transfer much or widely; and in 1915, of the increase of individual differences with equalization of opportunity [reference 166],—positions some of which led Spearman[3] to quote Binet[4] in a charge of psychological atomism.

[1] "General Intelligence," *Am. J. Psych.* 15.
[2] Hart and Spearman, *General Ability: Its Existence and Nature.*
[3] *Ibid.*
[4] *Les idees modernes sur les enfants*, 1909.

Confirming Thorndike, Thomson[5] found Spearman's type of correlation to exist in data gathered by pure chance, as in the random dealing of playing cards, from which any general central factor was known to be absent.

### CONSTRUCTIVE OUTCOME

This progress in the psychology of intellect evolved also a theory of the organization of intellect,—the central outcome, for pure psychology, of the work of Thorndike with intelligence examinations.

In 1914[6] he said that we were without any generally accepted hypotheses both of the organization of human nature and of the organization of human intellect.

### THE NATURE OF INTELLECT

The view of intelligence which came from Thorndike's application of objective methods is here summarized:

Our estimates of intelligence are numbers representing samplings of a certain universe [reference 279]. This universe is, for each individual, all the tasks he performs in adjusting his organism to his environment. The tasks are of many types, more and less closely correlated [reference 41]. Two tasks are classified together as of one type when their correlation is unity except for the random errors of measurement [reference 92]. The closeness of relationship among all the combinations of tasks, taken one at a time, two at a time, etc., and with varying weights, has patiently to be discovered by examining, one after the other, many instances of relationship.[7] Only after that can any hypothesis be proved. Since individuals vary in the level, range, and rate of their intellectual work, and especially since level is of preëminent import [reference 279], the three aspects must have separate measure. Single numbers representing the total intelligence of individuals result from summing or averaging many specific and imperfectly correlated abilities [reference 217]. It seems likely that the outcome of the examination of thousands of total and partial intercorrelations will bring evidence for three types of mentality, the abstract-verbal, the concrete-mechanical-constructive, and the social-executive [reference 178]. The universes of intelligent behavior sampled by verbal tests and by non-verbal tests are correlated about .7 apart from random errors [reference 223].

[5] *A Hierarchy Without a General Factor*, 1916.
[6] *Psychological Researches of James McKeen Cattell.* [ref. 163b]
[7] *Ibid.*

### OUTCOMES IN APPLIED PSYCHOLOGY

The outcome of the work of test construction has also affected applied psychology, perhaps most notably in the selection, classification, and educational and vocational guidance of the personnel attending institutions of higher learning, and employed in the army and in industry.

Space and time preclude further account of Thorndike's contributions in applied psychology, as well as the identification of contributions as unique, the tabular presentation of time sequences and of twenty salient features of each intelligence examination; and the quantitative valuation, severally, both of examinations and of other contributions.

### CHARACTERISTICS OF THORNDIKE'S WORK IN THE PSYCHOLOGY OF INTELLIGENCE

Certain traits obtain in Thorndike's work in the pure and applied psychology of intelligence: to choose important ends; to create and to handle adequately both hypotheses and technical methods; to bring into high light points of issue which resist analysis; to sense the bedrock of fact through the intermediary of technological means; to suspect pleasing conclusions; to search for neglected factors; to bring into his problems the bearing of every pertinent element in the world; to abhor discipleship in lieu of critical contribution, and—what is equally remarkable in the teacher, for whom circumstances make it both easy and conventional to accept the rôle of demi-god—to give to others always at least as much credit as is due and often seemingly more, never representing as his own the work of his students; and to express thought in a style instantly identifiable, with just his association of originality, brilliancy, strength, niceness and clarity.

## CONTRIBUTIONS TO THE FIELD OF EDUCATIONAL ADMINISTRATION

BY GEORGE D. STRAYER, PH.D. 1905
Professor of Education, Teachers College

EDUCATIONAL administration as a field of study for university students has been developed during the past twenty-five years. Courses dealing with administrative problems were given before that time, but they lacked both the content and the method

which we ordinarily associate with subjects taught in the university or in the better type of professional school. These earlier courses dealt primarily with current practice and with personal opinions, rather than with facts which had been scientifically determined. Professor Thorndike's interest in the whole field of education is nowhere more significantly shown than in his study of certain administrative problems, the basis for which he established in his scientific work in the field of educational psychology.

All of our investigations with respect to the classification and progress of children in elementary schools, in high school, and in higher education are based upon Professor Thorndike's contribution to the psychology of individual differences. He was not satisfied to report the work of laboratory investigations to the psychologists with the expectation that this would affect the practice of the schools. The proof which he gave of differences in achievement in the school subjects has had a profound effect upon the organization of schools and the classification of pupils.

The homogeneous grouping of children, the provision of special classes for the handicapped and for the more able pupils, the differentiated courses of study in the junior and senior high schools, together with the organization which makes possible these adjustments, are based upon the scientifically determined facts that individuals vary in ability and that education increases the differences in skill, in knowledge, and in power of reflective thought among the individuals composing any group.

The earliest scientific investigation of the problem of retardation and of elimination from schools was contributed by Professor Thorndike in 1907 [reference 80]. Subsequent investigations in this general field have, in the main, followed his technique. The facts revealed by this investigation gave a new impetus to the demand that the curriculum of the schools should be adjusted to the needs of individual children. A scientific basis was provided for carrying out the program which proposed that the schools should be made to fit the needs of children, rather than children made to fit the school.

The organization of schools to provide unique opportunities for education to all of the children enrolled in them is dependent upon our ability to measure the intelligence and the achievement of our pupils in school subjects. Here again the foundation for our present practice was laid by Professor Thorndike in his derivation of tests

and scales with which we measure individuals and groups. It was not possible to attack scientifically the problem of classification of pupils, the admission of young men and young women to college and university, or to diagnose adequately the particular difficulties under which pupils labored until these more accurate instruments of measurement were available. The administrator in public or private schools and in colleges and universities has become a scientific worker because of the technique developed by Professor Thorndike in the measurement of intelligence and in the derivation of tests.

Running through all of these contributions to the field of administration is the application of the statistical method. The statisticians had made little application of their formulae to the field of education prior to the present century. Professors Cattell and Boaz of Columbia University had developed the statistical method in the fields of psychology and anthropology respectively. It remained for Professor Thorndike to carry these techniques over into the field of education. With the publication of the first edition of his *Mental and Social Measurements* [reference 52] there was made possible the development of scientific work in the field of educational administration. Those of us who were fortunate enough to be students in his classes at that time were indebted to him primarily for guidance in our attempts to apply this scientific method to the field of administration. Since those early days, courses in educational administration throughout the United States have quite commonly included a treatment of the more fundamental statistical methods as an essential tool for the worker in this field.

In all of his contributions to the field of administration Professor Thorndike has given a splendid example of the scientific spirit. He has taken nothing for granted. We were shocked when he discovered that the sex of high school teachers made no difference in the retention of boys in this part of our school system. There are some of our colleagues who have not yet accepted the scientifically determined fact that languages and mathematics have no greater power to improve the mind as a whole than have forestry, electrical engineering, nursing or the sciences concerned with agriculture. We have felt the need of revising our procedures in the light of his determination of the fact through the measurement of the achievements of children in arithmetic, reading and other school subjects that there is rarely a real mastery of the simplest tasks by all of the children in a given group.

It is this willingness to face the facts, this freedom from tradition or superstition, that has made Professor Thorndike the leader of men who would develop the science of education. Those of us who work in the field of educational administration have been inspired by him.

## CONTRIBUTIONS TO STATISTICS

BY TRUMAN L. KELLEY, PH.D. 1914
Professor of Education, Stanford University

ON the first page of Thorndike's first statistical work he sounds the keynote of his attitude toward statistics when he says:[1] "There is, happily, nothing in the general principles of statistical theory but refined common sense, and little in the technique resulting from them that general intelligence cannot readily master." His interest is primarily in outcomes and not in methods, in direct action, not great mathematical refinement, and the rule of reason, not the rule of thumb. We are therefore to look for Thorndike's contribution not in great statistical refinement, but in breadth of application and in intimacy of association between thought and figure. Because of this, if we ask who, more than any other, has led schoolmen to-day to trust means, correlations, tests, and measurements, the only answer is "Thorndike."

In view of Thorndike's dominant interest it is no small tribute to his breadth of view that he wrote the following:[2] "The danger is that the attention of investigators will be distracted from the problems of pure measurement for measurement's sake, which are a chief source of progress in measuring anything. Perhaps not even one person in a million need feel this passion, but for that one to cherish it and serve it is far more important than for him to devise a test which thousands of teachers will employ." Though we will not say that Thorndike is the one in a million whose passion is pure science, still he has strongly felt the urge and has leaned that way, and he has never lost sympathy for and faith in pure science, just as he has never lost confidence in practical applications and common sense as headed toward fundamental truth. He himself is finely gifted with the kind of insight to which he referred in saying,[3] "A sense of when

[1] Reference 52, p. 1.
[2] Reference 200, p. 20.
[3] Reference 52, p. 4.

and how to use statistical methods is even more important than knowledge of the methods themselves." At that time (1904) he also wrote: "So far, indeed, physical anthropology has been the science to take the most advantage of them (statistical techniques) and in medicine they will perhaps find their greatest usefulness." We would say to-day that education and psychology were making the greatest use of them, and the reason dates back to 1904. The fact that medicine has not fulfilled his prediction lies not in the science itself, which teems with problems demanding quantitative treatment, but in the fact that it has not as yet had its Thorndike to shake it out of its contentment with categories.

To the thoughtful worker, quantitative problems are precipitated into statistical terms, but this should not be the only outcome. To the real statisticians the statistical setting does very frequently itself suggest new issues and throw new light upon the original non-mathematical problem. As Thorndike stated:[4] "One can use ingenuity in manipulating measurements as well as in devising experiments. . . ." A better illustration of such ingenuity can scarcely be found than the novel and effective statistical techniques of Thorndike's measurement of twins.

Certain of Thorndike's ingenious devices have not been generally adopted; for example, his median ratio coefficient of correlation; his freedom in calculating deviations from any available average, mean, median, or mode; and his coefficient of variability. It seems to the writer that the reason he developed these procedures lies in the fact that he has never made systematic use in the choice of statistics of the principle of least squares. Upon more than one occasion he has just fallen short of making explicit and utilizing the principle of least absolute error or that of least median error. That without one of these principles as a guide in derivation his techniques have been so essentially sound is due to his keen appreciation of probable and systematic errors in the resulting statistics. In short, he has used the principle of minimal error as an agency in proof but not in derivation. The present writer for some time considered the three procedures mentioned to be mathematically unsound. However, discard the principle of least squares as the sole criterion of fitness, and immediately these techniques become promising. It is very probable that the median ratio coefficient of correlation will some time be proven to meet some other minimal error requirement than that of

[4] Reference 52, p. 4.

least squares, and Thorndike's coefficient of variability may be expected to have a long history in connection with Poisson series. That Thorndike has not earned his statistical eminence through devotion to a single mathematical instrument is further evidence of his breadth of vision. We may rest assured that when the final chapter of statistics is written, an approach less catholic than his will be deemed but partial.

Dr. Thorndike has clearly pointed out and emphasized certain hazards not common to most social statistics but inherent in mental measurement. He has called attention to the importance of a zero point in mental ability, and has also been much concerned with the units of measurement employed and with the agreement of different units purporting to measure the same function. After noting that "the college student" may cover individuals enrolling for short or long periods, or part or full time, etc., and that a "child born" may cover one who dies within five minutes as well as an octogenarian, Thorndike writes:[5] "In the case of the college student and the child born, we are misled by what Professor Aikins has called the 'jingle' fallacy. The words are identical and we tend to accept all the different things to which they refer as of identical amount." To avoid this fallacy, Thorndike recommends, where possible, measures which are free of individual opinion and he further demands that[6] "we must also call equal only those things which can be interchanged without making any difference to the issue involved."

Dr. Thorndike credits "Galton and Cattell and others" with making valuable contributions to the use of measures by relative position, but it was he himself who broadcast the methods for handling measures of relative position.

His interest in such measures led him, as it had Galton and Cattell, straight to the normal curve. We all meet this mystic mountain and we must each decide what its effect upon our lives will be. Shall we circumambulate it, however devious the way? Shall we scale it, mine it, dedicate our lives to it, and enjoy the eternally placid view from its vantage point; or shall we harden our hearts to its appeal for our undivided affection, accept it as a shelter in case of storm, a look-out in case of need, but not as a home, through the windows of which all life may be seen? In brief, shall we avoid it, succumb to it, or criticise and use it? Thorndike did the last. His statement is:[7] "If in dealing with group measurements you can, *with-*

[5] Reference 52, p. 14. [7] *Ibid.*, p. 59.
[6] *Ibid.*, p. 15.

*out violating any known fact,* use the hypothesis that in a homogeneous group not subject to selection on the basis of the trait in question, any mental trait due to natural, as opposed to artificial, causes, is distributed approximately normally, do so." The policy here enunciated has become the established practice of the entire educational world, and two decades in which scores of investigations involving the assumption of normality of mental traits have been made have revealed no essential fallacy in this procedure. Dr. Thorndike himself, however, ever the first to sense a weakness in an expressed view, modified his recommendation in 1913: ". . . the approximations (to the normal distribution) are so imperfect that the assumption, though the best single one, is essentially unsafe." This is not his final word, however. Evidence led to the generalization of 1904, further evidence to the reservation of 1913, and still further to the potent conclusion of 1924,[8] "that intellect in the ninth grade, if measured in truly equal units, is distributed approximately (in a normal manner)." The various vicissitudes of the normal curve in Thorndike's mind are illustrative of his general technique. First, he used the curve and found it of great practical value; second, he doubted it; and third, he further studied it; and at all times he was neither afraid of it nor a slave to it. Though many statistical workers fall into one of two extreme classes, haters or lovers of the normal curve, Thorndike abides in the sparsely populated middle ground. No one has the right to say that the normal curve has clouded his vision or that he has not profited by the insight which it gives into new fields of mental life. The general sanity of his view in this matter has been wholesomely reflected in national, probably international, educational practice.

If space permitted, very similar stories could be told covering Thorndike's influence as it has affected correlation, the linearity of regression, multiple correlation, and probably most important of all, as it has affected the attribution of causal relationships in correlated data.

Another aspect of Thorndike's approach to problems is revealed in his handling of equivalent scores.[9] From a general consideration of the properties of correlated phenomena when imperfectly measured, he saw that situations could be divided into four classes: measures of the same thing (*a*) each perfectly measured, and (*b*)

[8] Reference 283.
[9] Reference 241.

each imperfectly measured; measures of different things, (*c*) each perfectly measured, and (*d*) each imperfectly measured. His analysis revealed that it was unsound to equate measures under conditions (*c*) and (*d*); that the equating under condition (*a*) was simple; and though he laid down the requisite rules for obtaining an algebraic solution under condition (*b*), he himself failed to carry his development to this conclusion. Contrast this approach with the very effective approach of a certain other psychologist, working much later but apparently without knowledge of Thorndike's article. This student derived the necessary algebraic formula for solving (*b*), but he did not reach the generalizations of Thorndike, for he drew no distinction between situations (*a*), (*b*), (*c*), or (*d*).

An entirely parallel case, involving still deeper analysis, is to be found in Thorndike's scheme for the classification of men in the Students Army Training Corps,[10] as described by the present writer. Thorndike here proceeded with all the logic underlying multiple correlation but without the actual mathematical technique itself. There is a "halo" of straight thinking in Thorndike's statistics that not only illumines a formulated statement, but actually impels him in the general direction of the quantitatively correct conclusion when the algebraic formulation itself is lacking. Thorndike shows a striking similarity to Galton in this capacity.

As a man, his interest is in his fellow men; as a philosopher he is inductive and quantitative; and because of both, he is an ingenious contributor to the measurement of mankind, its origins, connections, and purposes, and throughout all, a charitable, kindly, well-poised man of vision who sees things as they are.

## CONTRIBUTIONS TO THE PSYCHOLOGY OF THE ELEMENTARY SCHOOL SUBJECTS

BY ARTHUR I. GATES, PH.D. 1917
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TO consider Professor Thorndike's contributions to the study of the elementary school subjects and practices separately from his treatment of the general topics of education and psychology—which are presented in other papers—would be misleading if not impossible. To indicate and appraise all of his contributions result-

[10] *J. Appl. Psy.*, March 1919.

ing both from the application of general principles and from specific studies of the elementary school functions is beyond possibility in this account. It is necessary, therefore, to present a few samples of his work rather than a complete survey. Instead of selecting certain school subjects as representative of his work, I have chosen a few problems which will be encountered in organizing the work of the elementary school in any subject. The problems selected are as follows:

1. The choice of materials.
2. The choice of the form of presentation of materials.
3. The means of attaining proficiency.
4. The methods of adjusting to individual differences.
5. The methods of securing interest.
6. The measurement of ability and diagnosis of difficulty.
7. The development of desirable concomitant habits and attitudes.
8. The principles of organization of materials.
9. Special methods of teaching and learning, such as the "project method."
10. The methods of determining the objectives of elementary education.

1. *The Choice of Materials.* Professor Thorndike's studies in the psychology of learning led inevitably to a critical appraisal of the merits of the content of school subjects. His theory of learning, based on the principle of specific adjustment or habit formation announced in general form in 1899, and especially his pioneer studies of transfer, published early in 1901, led to the discard of the belief that subject matter was merely a tool by means of which mental powers were to be developed and character formed. In a chapter in his *Educational Psychology* [reference 46], published in 1903, Thorndike presents clearly the justification of appraising educational materials and forms of training for intrinsic merit. Busied with other pioneer work, it was not until about 1911, the year in which the course "Psychology of the Elementary School Subjects" was first offered, that he gave personal attention to the methods of evaluating materials. At this time, the task of criticising prevailing types of arithmetic problems as "unreal," "trivial," "never encountered in real life," "couldn't be framed until the answer was known," etc.—materials not published until 1921—was begun simultaneously with similar studies of the vocabularies of school books, the types of grammatical facts taught, and other types of elementary school materials. Actual counts of arithmetic operations found in school texts, of words found in all sorts of reading materials, were soon undertaken. Using

the telling remark to his classes that "There are twenty dissertations on Amsterdam Avenue," he stimulated among his students objective studies of the business, social and everyday uses of the types of the facts and skills then taught in the elementary school. He personally undertook and completed the most extensive study of all—the count of 3½ million running words in a carefully selected collection of printed materials, a task extending over ten years. Professor Thorndike's great influence on this type of work is attested by those who, sharing the work from the initial stages, have seen its growth to the present mammoth proportions under the caption "Scientific Study of the Curriculum."

2. *The Choice of Form of Presentation of Material.* With the materials to be learned or the skills to be acquired selected, the next task is that of setting up a learning situation such that mastery may be not only insured but achieved with maximum efficiency. In other words, the principles of economy in learning are demanded. That Thorndike is primarily responsible for an entire body of principles of learning which is highly applicable to the demands of education, all unbiased students admit. The fundamental theory embraces the principle of habit. Thorndike's great contribution was the verification of the principle and its reformulation in the explicit terms of "connections" or "bonds" in such a way that it became both intelligible and applicable not merely to motor but to any sort of reactions. When given in such dicta as "1. Consider the situation the pupil faces. 2. Consider the response you wish to connect with it. 3. Form the bond; do not expect it to come by a miracle. 4. Other things being equal, form no bond that will have to be broken. 5. Other things being equal, do not form two or three bonds when one will serve. 6. Form bonds in the way that they are required later to act, etc.," Thorndike's theory became readily applicable to the management of writing, reading, arithmetic, history and other school functions. Not content with a mere statement of his principles, he has himself illustrated in detail the applications to arithmetic, algebra, reading, history, writing, drawing, the language arts and other subjects and skills, although much of this material, not yet published, has been available only to his students. In this work, done in detail with extraordinary ingenuity, the student of education finds a wealth of fertile suggestions for improving the organization and management of the learning process in any subject.

3. *The Means of Attaining Proficiency.* Given well-chosen mate-

rial and methods of insuring the desired responses, there remains the problem of attained optimum proficiency. One may—to illustrate—learn the right facts in history and learn them well, or master the right operations in arithmetic with high accuracy, without achieving proficiency in reading and learning facts or high speed in computing. From his earliest to his latest writings, Thorndike has emphasized the factor of efficiency. Repeatedly he has pointed out that most pupils and adults work far below their maximum level. As a remedy for this deficiency he has invented or improved many devices: the instruments required to measure achievement and, consequently, to disclose the need for, and measure the amount of, improvement; forms of graphic display of progress to serve as a motivating device; the method of working under time limits as an incentive to effort; devices for checking results in order to show errors and deficiencies in working methods and to encourage the development of an independent technique of learning. Many of these desiderata are found in the "practice exercise" [reference 94] of which those published by Thorndike for use in arithmetic are among the first used in education. His *Arithmetics* [references 195, 196, 197], begun before 1911, show much more extensive and ingenious work on this phase of the problem of learning, a work in which he has been joined by many others in nearly all departments of education.

4. *Methods of Adjusting to Individual Difference.* From the first, Thorndike has been intensely interested in the nature, amount, significance and causes of individual differences in scholastic attainments and capacities. In all his writings on elementary school subjects, he has discussed the need and devised many ingenious methods of adjustment to varying individual capacities both the materials to be taught and the methods of teaching. Inasmuch as other treatises in this volume cannot overlook this major contribution it will not be elaborated further here.

5. *Methods of Securing Interest.* Other things—such as the desiderata suggested above—being equal, materials and methods of learning which are interesting are preferable to those less appealing. To the psychology of interest in the school subjects Thorndike has made contributions both theoretical and practical. His extensive studies of the original nature of man, of human instincts, capacities and "satisfyers" have been applied by himself and others to school management and the details of teaching the various subjects. His investigations of the conditions of work, of mental and muscular

fatigue, of the influence of air and humidity, etc., and his sagacious appraisals of the influence upon zeal of such matters as unnecessary copy work in arithmetic, of inappropriate pictures, diagrams, spacings of words and the like, suggest another line of approach to the problem of interest. His theory, I take it, is that interest is not to be secured by some simple and single formula or device. On the contrary, it results from the combined effects of many factors: the enlistment of instinctive trends such as the competitive urge or the thrill of demonstrable self-advancement; the avoidance of the "annoyingness" resulting from work too intense, too prolonged, or effort inhibited by unfavorable surroundings, and especially by securing the satisfaction which results from the choice of significant materials carefully adjusted to the capacities of the learner, not so difficult as to bring the chagrin of failure nor so easy as not to engage the learner's full powers of achievement. Interest, to Thorndike, is not a mysterious entity to be captured by waiting, verbal appeal, or trickery, then to be *attached* to a subject "like a tail to a kite"; it is an intrinsic symptom, not an extrinsic cause of compatibility between the worker and his work. His *Psychology of Arithmetic* [reference 252], for example, is replete with concrete suggestions concerning the means of securing, between the nature of the learner and materials and methods of learning, a harmonious working adjustment which is the basis of interest.

6. *The Measurement of Ability and the Diagnosis of Difficulty.* In another paper, Thorndike's contributions to the science of measuring scholastic products in the elementary field will be appraised more fully. How profoundly his inventions have influenced elementary school practices is there suggested. The work of educational diagnosis he has fostered not only by the development of tests but also by speculative and experimental analysis of the constitution of school subjects—as, for example, in his lengthy chapter on "The Constitution of Arithmetic Abilities"—and by studies of errors in pupils' performances. One of the most ingenious and influential of the studies of the second type appeared in "The Understanding of Sentences; A Study of Errors in Reading" [reference 189], and other similar articles. In these reports, Thorndike treated the numerous errors not as lapses or accidents, but as reactions as definitely produced by intelligible causes as are correct responses. Causes and results were sufficiently analysed in terms of the stimulus-response formula to illustrate a method of study which might be

fruitfully employed to secure greater insight into school functions and, consequently, to lead to improved teaching methods. These reports stimulated many students of education immediately to undertake similar studies of errors in other subjects. Analyses of functions by the method of correlation, by measurement, observation and experiment upon failures or near failures in the subjects, and by remedial training experimentally controlled by the equivalent group or other techniques round out a series of scientific approaches in the development of which Thorndike's influence has been primary. Such techniques as these have made possible the rapid approach of the study of the elementary school subjects to the strictly scientific plane.

7. *The Development of Desirable Concomitants, During the Mastery of the School Subjects.* The desire to develop, during the course of school work, many personal and social virtues such as initiative, trustworthiness, tenacity of purpose, etc., was not new in 1900, but the overthrowing of the doctrine of "formal training" and "mental discipline"—an accomplishment in which Professor Thorndike played a leading hand—left the need for new methods of procedure. Consistent with his own theory of learning and transfer, Thorndike repeatedly presented both the general and concrete forms, the guiding principles. Initiative, originality, reasoning technique, trustworthiness, etc., are not to be secured through any single formal exercise nor to be relegated to any particular curricular or extracurricular subject. On the contrary, they must be built up through "exercise and effect" in many different situations and subjects. In organizing a course in arithmetic or reading, it therefore becomes desirable to arrange situations in which these desired types of behavior are called into play. In his brilliant essay "Education for Initiative and Originality" [reference 179], this theory is illustrated in terms of the habit psychology, and in his system of arithmetic are found an abundance of devices requiring self-management, the keeping of records, self-analysis of errors, the planning of individual problems and projects, the search with little or no guidance for the solution of novel problems, the attack upon a new variety of "catch" exercises, the relating and organizing of experience by means of new types of review exercises. In his articles on "Reading as Reasoning" [reference 188] and similar topics, he revealed the complexity of higher mental processes which might be engaged in reading activities. By presenting illustrative exercises to use in con-

nection with ordinary reading material, he has exerted a profound influence upon the teaching of silent reading for the purpose of cultivating various types of comprehension, organization, and management of ideas. As early as 1906 Thorndike had framed the principles of analytic learning of abstract facts and offered many suggestions concerning the value of rules, definitions and other verbal formulae, of contrasting elements and other factors. During succeeding years these principles were extended and refined partly in his own work, for example, in his *Arithmetics;* and partly in the work of his students, for example, in Voelker's study of trustworthiness. In the writer's judgment, Thorndike's analysis and formulation, in terms of habit psychology, of the higher mental processes in analytic learning, in the abstraction and generalization of facts, in acquiring meanings and ideals, is at once one of the most brilliant and important of his contributions to education and psychology.

8. *Principles of Organization of Materials.* Given the proper materials and teaching and learning devices, there remains the problem of organizing the continuous course of study. The traditional method of organization was based on the developmental sequences of the subject. The subject matter was arranged primarily to be internally logical to the eye of the expert. While there have been many vague expressions of discontent with this principle of organization because of the apparent difficulties forced upon the inexperienced learner before Thorndike's discussions appeared, few constructive suggestions for betterment were offered. Thorndike for many years prior to publication of his *Psychology of Arithmetic* [reference 252] had been presenting to his students a principle of organization based on his general theory of learning and illustrated in detail. As far as I know, this was the first comprehensive presentation of the problem of organization from the viewpoint of psychology. Materials and operations are appraised from the standpoint of the pupil in the light of the recency and frequency of relevant habits then in operation. At each step one must consider what kind of responses to the new material the learner's equipment of habits will probably produce. Disregarding the question whether they appear to the sophisticated expert to be in a logical or conventional sequence, the steps should be arranged to secure the optimum facilitation from the developing habits. For Thorndike, adequate organization involves, furthermore, the provision for adequate exercise of all reactions; for exercise adequate in place, amount, length

and distribution. His painstaking analyses of the distribution of practice on arithmetic and other items throughout entire courses of study illustrate his work in this fertile phase of the psychology of learning.

9. *Special Methods of Teaching and Learning.* A survey of Thorndike's writings provides an immense amount of experiment and opinion concerning most of the familiar educational methods—drill, the practice exercise, the opportunistic procedure, the lecture, the demonstration, the recitation, the problem, the project. In his *Principles of Teaching* [reference 65], in 1906, several of these methods are treated in some detail and as late as 1922 in his *Psychology of Arithmetic* [reference 252], systematic analyses of drill, the opportunistic and project methods appear. From first to last it is apparent that Professor Thorndike has not been swept off his feet by the novelty of new devices and that he sought no panacea for all educational ills in any general method. He finds defects, or at least deficiencies, as well as merits, in all the familiar formulae. He favors one method or another depending on the nature of the function to be learned or the nature or purpose of the learner. Always he has shown respect for forms of direct learning; he has been disposed to favor the idea that the school is for wholesome and useful work rather than for indoor picnics. Thorndike's writings on these topics are of great service both to those seeking new ideas and to those interested in combating sheer radicalism.

10. *Methods of Determining the Objectives of Elementary Education.* Thorndike came into education in the days when books on scientific methods usually admitted that science should not concern itself with problems of ethics or ideals; that science should attempt to determine how to do things but not what should be done. The determination of the objectives of education or life was, presumably, to be accomplished by the methods of ethics or philosophy or other branches of study. Just what points of superiority the methods in these subjects possessed for work on topics of such paramount importance, was not disclosed. But later it became obvious to many that the ideals and objectives of living, like other facts, should be determined by scientific study for the good reason that the scientific method is the one best, the most valid, method. At the present time this contention is admitted even by students of ethics.[1]

Thorndike has given considerable attention to the objectives of

[1] For example see R. C. Givler, *The Ethics of Hercules* (Knopf, 1924).

education; a brief discussion appears in his *Educational Psychology*, 1903 [reference 46], a full discussion in his *Education; A First Book*, 1912 [reference 120] and in his *Original Nature of Man*, 1913 [reference 129]. It appears that from the first he rebelled against the idea that science cannot undertake the work of determining educational objectives. In his first book, 1903, he wrote: "It is the vice or misfortune of thinkers about education to have chosen the methods of philosophy or of popular thought instead of those of science." In his *Education*, he treats as one of the five problems of the *science* of education the determination of the "aims of education." That his own ideas have profoundly influenced the attitudes toward educational objectives is evident in the works and acknowledgments of Professor Kilpatrick and other leaders in this field. Nor has his influence stopped here. Thorndike's works have—in the writer's opinion—exerted a great influence on the gradually changing methodology of ethics and the social sciences generally.[1] A more profound influence than this can scarcely be imagined.

As suggested earlier, to consider Thorndike's studies of elementary school subjects as functions or projects unrelated to his other investigations would be utterly misleading. They represent, on the contrary, a detailed, practical application to a particular school subject or situation, of the entire accumulated mass of psychological fact and theory. He undertook to do what few persons, primarily investigators in pure science, have ventured to do, namely, to translate theory into, and test it by, detailed practice. During the process, Thorndike frequently admitted the difficulties of this task. Fainter hearts would have given up the task. But in his *Psychology of Arithmetic*[2] and his course of study in this subject arranged for schoolroom use (and in his unpublished treatises on the teaching of reading, spelling, writing, language and other subjects), Thorndike has contributed materials not excelled in brilliance by anything that he has accomplished elsewhere. These contributions are a unique demonstration that brilliance in pure science and ingenuity and practical insight in applied science are not incompatible. They reveal in relief his astonishing versatility. It is not alone the brilliance of one or a few studies but the number and variety of outstanding contri-

[1] For example, in a series of essays on social psychology, sociology, economics, political science, jurisprudence, ethics and other social sciences comprising *The History and Prospects of the Social Sciences*, edited by H. E. Barnes (Knopf, 1925), not only is the influence of Professor Thorndike's work very evident in the treatment of the subject but many of the authors, all eminent in their field, express their acknowledgment of his contributions.

[2] See reference 252, also 235, 94, 151, 195, 196, 197, 232, 288, 289 and 290.

butions to the problems of elementary education that places Thorndike in the position of acknowledged supremacy.

## CONTRIBUTIONS IN GENERAL TO EDUCATION

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ADMIRATION for an individual of superior ability and gratitude for his contributions to the progress of humanity are emotions which practically never find satisfactory expression. In the first place the emotions themselves are so deep and inclusive that it is difficult to find verbal symbols rich enough in content to serve as adequate vehicles of expression. Consciousness of impotence operates to inhibit even the feeble efforts which one is capable of making.

In the second place there never seems to be an appropriate occasion. It is not a single display of remarkable power which arouses admiration and commands respect. Such emotions are born of reasoned judgment based on manifold and repeated experiences. One "comes to admire" as mere "acquaintance with" ripens into a more intimate "knowledge of." Similarly, gratitude for a single act of assistance is almost certain to be given immediate spontaneous expression. But the deeper gratitude, born of a growing realization of the social significance and value of the achievement of genius, is more likely to strike its possessor dumb.

In the third place the influence of the contributions of a truly great man are exceedingly hard to trace. It is a characteristic of the superior individual that in thought and generalization he lives far in advance of his times. The creative products of his superior powers seem to fall on barren soil. Often it has happened that important contributions come to full fruition only long years later, and then through the efforts of other men to whom the credit is conventionally given. Every man, even the genius, builds upon foundations previously laid, and no man builds at all except with the aid of others.

It is not surprising, therefore, that the exact determination of merit is an exceedingly difficult matter. Perhaps when an individual has released a seed thought in the world by publication, it is enough to show that fact to entitle him to at least part of the credit for all its later developments, and it is exceedingly fitting that on the occasion of this twenty-fifth anniversary of Professor Thorndike's

connection with Teachers College, the thoughts and feelings of inarticulate thousands of teachers and other educational agents who have thus benefited by his labors should be formally expressed.

Probably the first thing to be said is that in making selections of contributions to be emphasized, the personal element must inevitably play a very large part. There is space and time to mention only a few outstanding contributions, and the scale of values used by one individual will not serve another. Nevertheless, while the precise selection and form of statement which follow are wholly individual, they are at the same time typical. Other individuals might select other items, and most certainly would express themselves in other terms, but all would acknowledge the value of Professor Thorndike's contributions, and all would gladly frame a corresponding expression of their appreciations.

Personally, I rank first among Professor Thorndike's contributions, Thorndike himself—his personality, his scientific spirit, his methods of thought and life. Science is one of man's mightiest tools, his greatest invention. But there are scientists and scientists. Science, in the lives of some, becomes an inhuman, machine-like god, superior to its creator, and to be followed blindly, even though the results are conclusions in conflict with more general but less definite data from other sources.

Professor Thorndike, however, is a scientist of quite another sort. While he personifies the utmost of the certainty, the care, the precision, and the impersonality which science requires, his work expresses also the humility, the vision, the open-mindedness which alone save the scientist from absurdity, and transform him from an impersonal machine to a philosopher and prophet. The scientist is one who not only knows, but knows also the limits within which he knows, and is keenly conscious that beyond these limits there are regions as yet unexplored. When Professor Thorndike speaks it is with the authority of facts that none may gainsay, but he himself is never misled by the conclusions reached. Always they are tentative, and always he is mindful of what lies outside the limits within which his conclusions are true. As he says himself, "Science differs from crude opinion by being impartial, by presenting facts in such a way that any competent observer can verify them and by certain ideals of care, accuracy, and close reasoning." But he also says, in speaking of tests, "A pupil's score in a test signifies first, such and such a particular achievement, and second, *only whatever has been demonstrated by actual correla-*

*tions to be implied in it.* Nothing should be taken for granted." If all scientific (?) workers in the field of education could but be moved to imitate Professor Thorndike's cautious example, the cause of scientific education would be delivered from many an unnecessary setback.

To me the spirit which has animated all Professor Thorndike's work is typified by the quotation, "Ultimately, indeed, every fact in human life is a case of the co-action of all the universe except the man in question, and the condition of the man in question at that instant. In taking anything short of all the universe, save him, and calling it the situation, we are abstracting—are replacing—the total effective situation by some element of it. Also, in taking anything short of the rich entirety of the man at that instant as the organism, we are abstracting—are replacing—the total effective conditions of the response by some of their main features."

No one can successfully attack the rigorousness of Professor Thorndike's scientific beliefs or practices. He explicitly states, "No response of any human being occurs without some possibly discoverable cause and no situation exists whose effect could not with sufficient knowledge be predicted." Also, he states that "the same situation acting on the same individual will produce always and inevitably the same response." Such a credo in a mediocre man leads directly to materialism and determinism of the Nietzsche type. To-day there are many whose so-called science is a snare to the unwary and a menace to human progress. The inevitable price the race must pay for the possession of a tool of power is its misuse by the ignorant or willful.

Professor Thorndike's work, however, is a constant stimulus to a clearer type of thinking and to rational idealism. It is always an inspiration to turn from perplexing, statistical and experimental problems in which the inexorableness of natural law has been more evident than the potentialities of control latent in human understanding, to the refreshing philosophy of one who has written, "The aims of education should then be to make men want the right things, and to make them better able to control all the forces of nature and themselves that they can satisfy these wants. We have then to make use of nature, to coöperate with each other, and to improve ourselves. . . . The study of human life in biographies and histories . . . (teaches) two great lessons: first, that on the whole and in the long run public esteem is given to moral greatness, not to wealth or position or success; second, that the world is more than a place where

you eat and sleep and endure work for the sake of a few cheap, animal pleasures, that it is full of great issues, unselfish motives and heroic deeds. . . . The apostles and soldiers of the ideal in whom service for truth and justice has become the law of life need not despair of human nature, nor pray for a miracle to purge man of his baser elements. They are the sufficient miracle; their lives are the proof that human nature can change itself for the better—that the human species can teach itself to think for truth alone and to act for the good of all men." [references 65, 120, 129.]

I rank second among Professor Thorndike's contributions to education his emphasis upon the need for making adjustments to individuals. I do not refer to his extensive contributions to the psychology of individual differences, but to his teaching that because of such proved differences in children, the road to improvement of education leads in the direction of intelligent adaptation of educational means and procedures to the natures of individual children.

The discovery of the child in education is often ascribed to Rousseau. Certain it is that since his day more and more attention has been paid to child nature. But to this day there are few teachers whose belief that children differ is strong enough to make their actions in the classroom conform to Professor Thorndike's suggestions. "As a result of the differences originally present or produced by growth and training, education has to be specialized in means and methods. The competent teacher expects variety in human beings and examines *each pupil* to learn what he really is and needs. . . . It would be wasteful for a man of a certain original nature and training to be taught to manipulate logarithms, and still more wasteful for a man of a certain other nature and training not to be. Here, as everywhere, the material—that is, the persons to be educated—decide in part what the proximate aims of education should be." It is fifteen years since that sentence was written; years which have seen the gradual shift of emphasis in teaching from subject matter to children, and the evolution of the Dalton plan, the Winnetka plan, practice tests, and other forms of individualized instruction which to-day are just coming into public favor. Yet even at that early date Professor Thorndike wrote "Books to be given out in loose sheets, a page or so at a time, and books arranged so that a student only suffers if he misuses them should be worked out in many subjects. . . . Great economies are possible by printed aids. . . . A human being should not be wasted in doing what forty sheets of paper can do."

Once Professor Thorndike's point of view is adopted, a number of changes in educational practice inevitably follow. The first of these to which he has greatly contributed is the classification of children according to ability. Very early he was pleading especially for attention to the gifted. "To discover such a (gifted) one, to prepare him to do the work and to give him the opportunity to do it, is an important aim of education—as important, perhaps, as the diffusion of knowledge among a thousand others."

Through the ages there has gone on continuously a certain sifting of knowledge and the selection for transmission to the next generation of what the adult mind regarded as best. But the invention of educational measuring instruments made it possible to make selection on a more rational basis than ever before. Thus, in the account of his handwriting scale published in 1910 [reference 103], we find not only new and more objective proof of the inefficiency of school training than ever before, but concrete suggestions for the improvement of efficiency through objective definition of aims. In that monograph he states specifically:

"The classroom teacher has to measure the quality of a single pupil's handwriting. . . . If she uses the scale, . . . her ratings will have a definite meaning to the pupil. . . . Whoever has any occasion to define a standard of quality in handwriting can define it unmistakably and conveniently by the scale. . . . A supervisor can inform all the teachers of, say, grade 7 that the minimum requirement is, say, quality 11 at a rate of 50 letters per minute, that the average pupil must be made to write at quality 13 at a rate of 60 letters per minute, and so on. Whatever standard is set will be absolutely defined by those who set it and will be clear to all those who are to follow it. The pupil himself may profitably know and use the scale. He may see by it what is expected of him and may tell how nearly he reaches the standard and how much he has gained."

Objective definition of aim has since become a well-nigh universal slogan wherever measurement in education is carried on, and great have been the benefits resulting therefrom.

The attempt to define aims objectively, however, leads to the evaluation of the products of educational effort. Evaluation brings to light what Thorndike calls the error of inertia, or the continuation of the wide distribution of facts long after more serviceable facts are at hand; the error of imitation, or the tendency to add to the course of study more and more of the same thing rather than some

more desirable knowledge of a different sort; and the error of puritanism or the preference of any individual for the varieties of knowledge which by nature he avoids. Professor Thorndike has struck long and vigorously at all three of these errors among others, and many persons there are who agree to ascribing to his efforts the present movement for the vitalization of the curriculum on the basis of scientific studies of both subject matter, child, and adult life.

The attempt to define aims objectively leads inevitably, also, to the clear formulation of the principle of Limitation of Training. To quote Professor Thorndike:

"That children in the last two grammar grades can write so much better than adult women teachers do customarily write is an important fact. Considering it in connection with the fact that above quality 11 there is very little difference in legibility, one is tempted to advocate the heresy that children are taught to write too well. I personally do advocate it. The value now attached to high qualities of handwriting is, of course, largely factitious."

To-day there are in the United States more intelligently organized and administered curricula, more attempts to adjust subject matter to children's needs, more enrichment of textbooks and courses of study, less useless drill and less meaningless pupil activity than one who knew school conditions at the time Professor Thorndike began his work would have believed possible in one generation.

Great as all these contributions are they dwindle into insignificance in the estimation of many persons beside Professor Thorndike's contribution to methods of teaching. The schools of the past were many times revolting torture chambers for teachers and children. School tasks of meaningless memorization and drill were enforced by corporal punishment. Autocratic domination by authority and ceaseless warfare between teacher and child were once the rule. In the light of present practice it is sometimes hard to realize how great is the progress we have made. Professor Thorndike did not initiate these changes, but he has contributed greatly to them. I need only to refer to his formulation of the laws of learning to win instant approval of my statements from thinking teachers everywhere. Yet few realize how completely he, himself, subscribes to and has taught the most modern procedure in classroom teaching. For instance, he says:

"It is a paradox in educational theory that although everybody admits that the happiness of the world is an important ultimate aim, attempts to make schools minister at all directly to the happiness of

scholars are often decried as undignified, soft pedagogy, trifling with the serious work of education. . . .

"It would be the acme of wicked folly if we denied little children happiness for no purpose. And it would be a brutal consequence of adult control of education if we failed to give children their kind of happiness merely because as adults we did not value it as highly as their happiness when old.

"In the days of our forefathers . . . even the wisest of men could not hope for much happiness for mankind in this world. So they urged the importance of educating man to despise happiness.

"Their very spirit, however, under present conditions makes the wise man despise an idle resignation to causes of unhappiness which modern science can control. Since victory over disease, pain and deprivation is possible by knowledge, the thing to despise is ignorance. . . . The ideal life is one of work and recreation, both enjoyed, the successful man is happy in his work and wants it."

A careful search through Professor Thorndike's early writings on methods of teaching will show him putting emphasis on purposing by children, getting them to help themselves and providing them with meaningful activities worth while to them in terms of their childish interests. How far-reaching such contributions are destined to be it is too soon to tell, but all will agree that they have tremendous transforming powers. To-day we are slowly and laboriously changing classroom methods to conform to Thorndike's formula. To an increasing degree, thanks to the aids which he has furnished, our schools are becoming children's utopias, temples at last of childish vision, achievement, and happiness.

I cannot conclude my list of Thorndike's contributions to education without mention of one of a more technical sort, which even yet is so far beyond the development of present teachers that his suggestion has at present borne little fruit. I refer to his clear formulation of the fact that in education the master problem is validation. Who but Thorndike could have written fifteen years ago, "Even superior teachers would have to confess that again and again they say this, or ask that, or order the other, not because they know any good reason why the statement, question, or command should produce the desired response, but just because they do not know what to do or because that particular statement or question happened to come to mind." Unfortunately, the condition described is still true. In education we do not know. We only guess or vaguely wonder. Yet by his life

and precepts Professor Thorndike has shown us the way and we have but to follow along the trail he is blazing to learn and to control.

So let me end, as I began, by emphasizing the importance of Professor Thorndike's contribution of scientific method and spirit. His work and life are really a call to service; and we who benefit by his unselfish labors can find no better way of expressing our admiration and gratitude than by following the plan he, himself, has pointed out. For he has written, "The art of human life is to change the world for the better—to make things, animals, plants, men, and one's self more serviceable for life's ends. . . . Man improves education as he improves any human activity—by openminded thought about it, by learning the results of existing forms of it, by experimenting with other forms, and by clearing up and making reasonable our notions of what changes we should make in human beings and of how we should make them."

## TECHNICAL CONTRIBUTIONS TO EDUCATIONAL MEASUREMENT

BY WILLIAM A. McCALL, PH.D. 1916
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EVERY teacher endowed with fertility of ideas soon finds himself saying to himself, Would that I were fifty men! Thereupon he turns to his students in search of those who have sufficient talent to permit a partial multiplication of himself. Since no teacher has poured himself more generously through students, we can say that Thorndike is what he individually has contributed, plus what he has contributed through his students and the students of his students, plus what he has contributed through his readers and the readers of his readers, minus such coöperating additions as have been made to this immense total by the students and readers themselves, though the subtraction is mentioned on this occasion merely out of respect for the principle of scientific accuracy with which Thorndike has striven to endow the writer.

An editorial limit of eighteen hundred words on this article forbids any attempt to survey this geometrically multiplying contribution, and hence has compelled the adoption of another plan of presentation, namely to list barely and somewhat boldly the relatively technical

ideas and techniques proposed by American educators during the last twenty years which, in the hasty and confessedly biased judgment of the writer, are of greatest moment to educational measurement; and of indicating by a T or ST or A placed after each whether it is chiefly a contribution by Thorndike, or a student of Thorndike, or another, respectively. Purely statistical procedures not peculiarly connected with educational measurement, such as various forms of correlation and methods of expressing reliability, are omitted from the following list, since they are doubtless dealt with in another article.

VALIDITY

1. Early emphasis upon power or difficulty tests of functioning abilities rather than tests of knowledge with a consequent guidance of instructional emphasis in that direction (T and ST). The Thorndike Reading Scales and the Hillegas Composition Scale are illustrations of this emphasis.

2. Analytic study of the validity of educational measurements, where rate of work is measured and allowed for instead of leaving it relatively uncontrolled as is done by difficulty tests (ST). Courtis has been the conspicuous leader in this movement, though one of the most brilliant articles is written by him and Thorndike in collaboration.

3. Provision for the social worth of test items (T and ST). Perhaps the three studies which have most vitally influenced educational measurement from this point of view are Thorndike's word count of the English language, Ayres' spelling count, and Wilson's survey of arithmetic in common use.

4. Provision for test items that will be diagnostic (A). Monroe has been the most forceful advocate of diagnostic test items, though Thorndike has done brilliant work in the diagnostic interpretation of results from reading tests.

5. The overlapping technique for measuring the validity of test items dichotomously scored (ST). This method was first used by Vincent.

6. A technique for measuring the validity of test items which are dichotomously or otherwise scored (ST).

RELIABILITY

7. Leadership in the movement to secure reliable measures of ability by increasing the length of testing time, and by multiplying the number of alternative forms of tests (T).

8. A technique for measuring the reliability of test items when dichotomously scored and when dichotomously or otherwise scored (ST). Both the above-mentioned techniques are as applicable to the measurement of the reliability of items as to the validity of items.

### STANDARDIZATION

9. Provision of norms for tests (ST). Rice is generally considered the originator of standard educational tests.

### SCALING OF TEST ITEMS

10. Empirical determination of the difficulty of test items both within a defined group of pupils and for several overlapping groups combined (ST). Buckingham developed the methods for determining the P.E. difficulty of test items.

11. Subjective determination of the difficulty of test items (T). Thorndike has recently demonstrated a substantial correlation between the difficulty of items as judged by several experts and their difficulty as determined empirically.

12. Objective determination of the difficulty of test items and of the total test (ST). Courtis was the earliest to use this approach to difficulty, though Thorndike has constructed intelligence tests on this basis.

### SCALING OF TEST SCORE

13. Conversion of the Cattell-Fullerton theorem that equally often noticed differences are equal unless they are always noticed or never noticed from a base of numerous judgments made by a single individual to numerous judges giving a single judgment each upon a single specimen, and the application of this converted theorem to the scaling of product scales (T). The Thorndike Handwriting, Composition, and Drawing Scales illustrate this application.

14. A technique for scaling product scales whereby at one stroke the foregoing process is simplified, made less laborious, and made to yield a scale score directly which is comparable to performance scale scores (ST).

15. Specialization in types of product scales whereby compositions are measured from the point of view of function, whereby composition and handwriting scales are made more diagnostic and possibly more valid, and whereby scale units are made more exact or are better standardized (ST). Reference may be made to the Lewis Composition Scales constructed from the point of view of function,

to the Willing Composition Scale which separates the mechanical features from the others, and to Courtis's demonstration that size of product scale units varies with expertness of the group giving judgments, and hence the necessity for securing a standard group. Much of this work has been done by students of Thorndike, though not all of it.

16. The adaptation of the age scale and quotient scale to the measurement of educational achievement, thus providing for educational age, reading age, and the like, and educational quotient, reading quotient, and the like (ST).

17. The accomplishment ratio (ST). This was invented by Franzen, though Buckingham and Monroe devised the achievement quotient at about the same time. The latter is similar to but not identical with the former unit.

18. The T, G (Grade), B (Brightness), and F (Effort or Efficiency) scales plus their application to a standard group (ST).

19. The C scale system (T and ST). This system has evolved through four stages: (*a*) Thorndike used it first for calculating class scores only, the scale point being the 80-20 per cent point; (*b*) Woody used it next for calculating class scores only, substituting the 50-50 for the 80-20 per cent point; (*c*) Kelley introduced improvements which made it possible to use the method for calculating pupils' scores; (*d*) Van Wagenen evolved a simplification of the Kelley method which made it possible for relatively untrained workers to use the method for calculating pupils' scores.

20. The conception of a sort of mental meter stick, against which to scale and calibrate all tests and current efforts to effect such a calibration (ST).

21. The conception of an absolute zero and an absolute scale and current efforts toward the development of such a scale (T).

22. The conversion of teachers' judgments of pupils and pupils' records on teachers' examinations into scores comparable from teacher to teacher, examination to examination, and from both to standard tests (ST).

### SCORING

23. Organization of test materials for objective scoring (T). Probably the Thorndike Visual Vocabulary Scales were the first to make use of the alternative type of test item.

24. A technique for an optimum, directionally validated scoring

key which gives due regard to the difference between the mental peculiarities of children and those of adults (ST).

25. Correction formulae whereby speed and quality on rate tests can be brought together into a single score (T and ST). Courtis and Thorndike have done the most scholarly work at this point.

26. Provision for improving the accuracy of scorers (T). Thorndike early recognized the need for improving the accuracy of the scoring of compositions in particular and provided materials for the training of such scorers.

TESTS AS TEACHING INSTRUMENTS

27. Inventory tests (ST). Osborne has done the most effective work here.

28. Practice Tests (ST). Courtis has led this development.

29. Standard Test Lessons (ST).

30. Scaled curriculum (A). Ayres' Spelling Scale is the earliest illustration.

Thus out of 30 major contributions to educational measurement during twenty years, Thorndike and his immediate students have accounted primarily for 28. If we omit Courtis from this reckoning, since he is probably more a contemporary than a student of Thorndike, we still have 24 contributions credited either directly or indirectly to Thorndike.

## CURRENT INVESTIGATIONS

BY PERCIVAL M. SYMONDS, PH.D. 1923
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THE opportunity for doing intensive research did not come to Dr. Thorndike until the creation of the Institute of Educational Research, authorized by the Trustees of Teachers College, February 10, 1921. Although the *Teachers College Record* of November, 1921, states that the Institute of Educational Research, Division of Psychology, began active work January 1, 1921, it was not until September of that year that the office staff was formed and work formally got under way. Dr. Thorndike had long had the desire to create such a research institute, but the war did not permit the fulfillment of his desires until 1921. It is part of his philosophy that those who are competent should have the opportunity to do research.

In his *Education* [reference 120] he says, "The sum of knowledge of nature and of man is increased indirectly by the intellectual labor of a few exceptionally gifted men and women. Probably not one in a hundred of the pupils who enter our schools could, even with the most advantageous training, discover new truth—add to the world's intellectual capital. But the work of the one in a hundred, or in a hundred thousand means an enrichment of the world, a higher percentage of satisfied wants, for ever after. To discover such a one, to prepare him to do the work and *to give him the opportunity to do it,* is an important aim of education—as important, perhaps, as the diffusion of knowledge among a thousand others." Dr. Thorndike has been true to his own ideal.

Among the first projects of the newly established Institute was a study of the psychology of algebra, under a subvention of the Commonwealth Fund. The experimentation, study of textbooks and organization of the material of this investigation occupied a large share of the attention and time of Dr. Thorndike until June 1922, when the work was virtually completed. Much of the material first appeared in the form of periodical articles in the *Mathematics Teacher, School Science and Mathematics, School Review,* and *School and Society* [see references 253–259, 240, 245]. All the work on the psychology of algebra was assembled and published by Macmillan Company in the book *The Psychology of Algebra* [reference 261].

*The Psychology of Algebra* contains many contributions of outstanding importance. Dr. Thorndike has made an extremely simple and lucid statement of elimination among high school students; he has made a study of the occupations of high school graduates and non-graduates. With Miss Cobb he made a study of the intelligence of high school pupils and the relation of success in courses in algebra to intelligence. Two studies in coöperation with Miss Woodyard have special importance in justifying the existence of algebra in high school and helping to select and evaluate the material of the algebra course. The first of these is a study of the uses of algebra in other high school subjects as shown by an inventory of high school textbooks. The second is a study of the uses of algebra and geometry in general intellectual reading as shown by an examination of the *Encyclopedia Britannica.* Several chapters are devoted to defining algebra in terms of its learning, thereby bringing out difficulties in learning resulting from inconsistencies in operations or the use of symbolism. One chapter is devoted to an analysis of and keen commen-

tary on existing standard tests. Perhaps the core of the book is the discussion of the constitution of algebraic abilities, which is an attempt to analyze the algebraic learning into its fundamental constituents or "bonds." The experimental work used as a background for this part of the book was an exhaustive inventory of the bonds in four representative modern algebra texts. Such an analysis uncovers many habits over- or under-emphasized and supports the contention that there is need for a "general increase in the amount of practice in computation." A valuable chapter, partly the work of Mr. Orleans, shows how this drill may be facilitated by suitable exercises. Although the need for greater accuracy in manipulation is stressed throughout, this is not at the expense of understanding or loss of meaning, for it is maintained that meaning comes only with acquaintance and familiarity. With Mr. Orleans, Dr. Thorndike made a study of pupils' interests in high school subjects and also made a study of the interest of pupils in various features of algebraic learning. With Mr. Symonds he made a study of special disability in algebra and the degree to which ability in algebra is specialized as apart from average ability. The influence of this volume is not difficult to estimate. It has had an immediate effect on the teaching of algebra by the more progressive teachers. Evidence of this is seen in the greater number of articles of a scientific nature appearing in the *Mathematics Teacher, School Science and Mathematics* and other periodicals as contrasted with the argumentative type of article of a few years back. But the influence of the work is spreading to other high school subjects. Workers in science, social studies, and language are busy filling in the gaps in their fields under lines laid down by Dr. Thorndike in his study of algebra.

Not content to propose the principles on which the learning of algebra may most surely take place, Dr. Thorndike has written a series of Junior High School Mathematics texts which put into concrete practice the principles proposed in *The Psychology of Algebra.* This series is being published by Rand McNally and Company.

While engaged in this work in algebra, Dr. Thorndike found time to carry on several other projects. He collaborated with Professor Upton in conducting an experiment in the latter's class in the teaching of mathematics. This experiment was in the learning of an abstract subject, choosing physics as the material. He concluded from this study that learning an advanced and highly abstract subject is not

different in character from the learning of a high school subject by a boy or girl.

Another project entered upon by the Institute of Educational Research in its first year was an inquiry into the effects of the study of Latin upon the range of English vocabulary and upon logic and carefulness in reading English. These studies may be taken as models of transfer studies. Groups taking and not taking Latin were equated according to the abilities under investigation at the beginning of their high school course, and the differences between growth in the functions—reading ability as measured by the Thorndike-McCall scale and vocabulary as measured by the Thorndike Test of Word Knowledge and Carr Vocabulary Tests—were found over one, two or more semesters of study. After a semester's study the pupils studying Latin showed superiority over pupils not studying Latin both in reading ability and vocabulary ability. In succeeding semesters this superiority did not show nearly so large an increase. The superiority in vocabulary ability was due largely to words of Latin origin, the Latin group showing no superiority in gain over the non-Latin group in words of Anglo-Saxon origin. This work was a part of the Classical League Investigation. The findings of the study are secure, although they have been given an unwarranted interpretation in the report of the Classical Investigation. Although the Classical Investigation report drew conclusions from these and other similar studies as to the validity of the study of Latin, Dr. Thorndike's studies do not support such conclusions. A pupil studying Latin words may be said to be learning English words (over the 500 most common English words which are largely of non-Latin origin), but the gain of the "Latins" to the "non-Latins" is only about in the ratio of 21 to 20.

Another major study started by Dr. Thorndike in the spring of 1922 and carried over through 1923 was an investigation of the disciplinary values of high school studies. "Over eight thousand pupils were measured in respect of their general intellectual power before and after a year of work, and the gains made during the year were put in relation to the subjects studied. The results are in pronounced opposition to the traditional view that certain subjects produce much more general improvement in ability to think than others; and that among the subjects taught widely in high schools algebra, geometry and Latin are the three that do this to the greatest extent." Certain features of this experiment are capable of refinement and the testing is being repeated on the same large scale with

additional data. This repetition will test the validity of the original findings. These results are of the greatest importance in helping educators to continue to revise the secondary school curriculum without the hampering restrictions of tradition. The results are in line with Dr. Thorndike's assertions in 1901, following his original experiments with Woodworth on transfer.

Along with these experimental data, Dr. Thorndike has collected data concerning educators' beliefs with respect to the disciplinary values of studies. In general educators place Latin and mathematics low in their estimation of their disciplinary value. "The traditional assumption that lessons train the mind much more than life does, finds little support." There is a positive correlation between a teacher's opinion of the disciplinary values of subjects for pupils and his opinion of the effect of these studies on himself. Contrary to popular impression there is a positive correlation between interest in a study or activity and its disciplinary value for that person. These data were collected several years ago while Dr. Thorndike was teaching educational psychology.

Such widespread testing as that carried on for the transfer study cannot fail to yield significant by-products.

"A comparison of the white and colored children in the high schools of one large western city, in respect of standard tests of intelligence, shows that the colored pupils are far below the white (only 4% of colored are equal to the average white) and gain only three-fifths as much in a year" [reference 271]. These measurements are Dr. Thorndike's contribution to racial psychology. They were obtained under conditions that must satisfy most of the critics of the earlier studies of race differences.

"A comparison of pupils, each with himself a year later, showed that, for the kind of pupil who progresses to Grade 10 or 11 or 12, mental growth does *not* stop at about the age of fifteen, but continues at least as long as the pupil is in attendance at high school." We are still in the dark as to the nature of mental growth after the age of 14, but this study dispels the false interpretation of Army testing data that mental growth stops as early as 13 years, at least for those who continue on through high school.

With Miss Robinson, Dr. Thorndike has demonstrated the wide diversity of programs of high school pupils in large city schools. "Among a thousand pupils in the same grade (the tenth) in the same city, there will be about 700 different programs. The largest number

of pupils among the thousand who are taking the same studies will be about 35."

In 1922 Dr. Thorndike started on the third of the major projects thus far undertaken by the Institute of Educational Research—a study of units of measure of intellect and capacity. This has been a heroic task. Dr. Thorndike encountered and overcame many difficulties in the determination of an absolute scale of levels of difficulty. Vast amounts of testing on all levels from the imbecile to the adult genius have laid the foundation of an intelligence scale which, embodying all of Dr. Thorndike's rich decade of experience with intelligence testing, promises to be far superior in both validity and reliability to other extant tests. It is difficult to write with accuracy concerning this investigation as the results are still to be printed in a forthcoming volume. One may safely say that this volume will be monumental, perhaps a *magnum opus*.

In the first year of the Institute, Dr. H. A. Toops undertook a study in the field of educational and vocational guidance which had Dr. Thorndike's advice and guidance at every step. One thousand seven hundred and fifty-three pupils in the eighth grade were tested during 1922 and 1923 in tests of so-called general intelligence, tests of accuracy and speed in various forms of clerical work, and tests of skill in handwork. The report of these tests was prepared by Dr. Toops and printed as a Teachers College Contributions to Education. This testing is being followed by follow-up work continuing over a period of several years. To use Dr. Thorndike's own words, "The careers of these children in school or in industry have been followed to see how far the prophecies and recommendations made on the basis of the examination have proved correct and helpful. At least one visit has been made to the home of each child or to the school, if the child is still attending school. They will be followed through a second year, at the end of which both a school history and an industrial history will be available for over a thousand of them. The school histories already confirm the expectation from previous studies that the intelligence tests prophesy school success sufficiently accurately to be of notable practical service. They indicate that if philanthropic motives lead communities to require school attendance to a given age or to a given grade or to some combined age-grade station, a new type of education should be provided for the less intellectual third of the children. From much of the present curricula for Grades 6 to 10, they may learn only discouragement and failure." Much has been written

about the use of tests in educational and vocational guidance. This, so far as I know, is the only instance where the endeavor has been made to determine exactly what the tests are good for in the matter of vocational guidance.

Before and during the war Dr. Thorndike assembled much material that facilitated the testing of applicants for college admission. The Columbia College experiment started in 1919 with the use of the Thorndike Intelligence Examination for High School Graduates. During this latter period Dr. Thorndike has assimilated many data regarding these tests and has assembled an entirely new series beginning in September 1925 and running for several years. Much of his material in subject matter testing he has turned over to Dr. Ben Wood. Dr. Wood has gone forward in this work of preparing and studying new-type tests for college admission and placement. To this work Dr. Thorndike has given advice and encouragement. During the algebra inquiry Dr. Thorndike prepared a new type of algebra examination for the Middle States College Entrance Examination Board. Although these specific tests were not accepted by the board, the discussion which they provoked has proved valuable, and facilitated the relaxation of previous archaic test methods employed by the College Entrance Board.

In his work on units of measuring intelligence a number of subsidiary monographs by Drs. Orleans, Clark, Hunsicker, Vincent, Bailor and others have drawn on the data and material assembled.

In connection with the Latin investigation Dr. Grinstead and others made a census of the occurrences of each word in over five thousand ordinary book pages (1,700,000 words in all), thereby extending Dr. Thorndike's own list of the 10,000 most important words in English, and showing that, except for the five hundred commonest words of all, over half of the words at any level of importance are of Latin derivation.

In the fall of 1924 Dr. May and Dr. Hartshorne started research on moral and religious development and education. This inquiry follows lines suggested by Dr. Thorndike who gives guidance and advice at every step. This inquiry is especially difficult as there are practically no tools for measurement and no technique of investigation. The progress of this study, therefore, has been slow to all outward appearances. The first year was devoted to the construction of measuring instruments, particularly relating to honesty in school work.

In the summer of 1925 Dr. Thorndike began work on an investigation of adult learning, financed by the Carnegie Corporation.

Space also does not permit extended discussion of noteworthy speeches delivered and popular articles printed since the establishment of the Institute. In some respects Dr. Thorndike is less well known to the student body of Teachers College now that he is devoting all his time to research than when he was teaching and advising students. Although he refuses many invitations to write or speak, his contacts are to-day more significant and more noteworthy than ever. For the American Academy of Political and Social Science he wrote on the motives for thrift [reference 220]; for *Harper's Magazine* he wrote popular articles on "Intelligence and Its Uses" [reference 217], "The Psychology of the Half-Educated Man" [reference 222] and "The Psychology of Labor" [reference 243]; for *Science* he wrote on "Psychology as a Life Work" [reference 266], and "Psychological Research for Aviators [reference 204]. In the fall of 1921 he gave the convocation address at the opening of Columbia University, speaking on "Measurement in Education." During the summer of 1924 he was one of a number of psychologists to deliver lectures in a symposium on psychology in Columbia University. In this series Dr. Thorndike spoke on "The Psychology of Labor and Capital." At Section Q of the American Association for the Advancement of Science in December, 1924, Dr. Thorndike read an outstanding paper on "The Nature of Intellect."

This recital of the past few years is the recital of the tireless energy of a prodigious intellect. When one reflects on the immense and confining labor of statistical analysis which comprises the bulk of Dr. Thorndike's research, one marvels at its amount. When one reflects on the number of different projects in which Dr. Thorndike finds himself interested and actively engaged at one time, one marvels at his breadth of interest. And when one reflects on the fundamental nature of his researches, one marvels at his insight which sees the essence of a problem and attacks it directly.

# IV. Estimates of General Influence in Psychology and Education

## "THORNDIKE IN CHINA"

BY TIMOTHY TINGFANG LEW, PH.D. 1920
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TO write about "Thorndike in China" within the limit of fourteen hundred words in English is not an easy task for a Chinese. Thorndike is one of the four or five best known foreign names in educational circles in China. To write an adequate account of his influence in this country would be writing the history of the so-called new educational movement in China in the last six years. In this history you will find names of chancellors of national universities, deans of graduate schools and normal colleges of education, professors and instructors in the departments of education of colleges and universities, general secretaries and founders of the National Association for the Advancement of Education (the most progressive educational association in China to-day), members of boards of trustees and collaborators in the Mass education movement, translators of scientific works in education, editors of and contributors to the outstanding educational periodicals—for the Thorndike disciples are multiplying rather fast in China. His "Laws of Use, Disuse, and Effect" are becoming the laws of learning here also. The notable success which the Thorndike teaching has had in China has created many "annoyers" as well as "satisfiers." Recently some educators trained in other schools in America had to bear the burden of proving the proposition that "Teachers College graduates are not necessarily the only best educational leaders." The students of Teachers College who had the privilege of studying directly under Thorndike at his seminar, received approval and disapproval from him, sometimes at a matriculation examination for a Ph.D. or during the ten minutes interviews on Tuesdays and Thursdays during his brief sojourn in the

city of New York, between his research work and commuting hours. These students returned to China either with or without degrees and diplomas from Teachers College, but all brought back a set of "the three terrible volumes," from the Teachers College Bureau of Publication. Even the poorest among the students secured at least a second hand copy of the *Briefer Course*. If anyone had failed to master the contents of either his three volumes or of the *Briefer Course,* he would be sure to master it through his teaching or writing when he came back.

In all the Teachers College alumni in China whom I have met, or heard or read a distinct individuality due to the influence of Thorndike is unmistakably evident. The lack of space prohibits the giving of statistics, but I can at least vouchsafe for one. "Bonds" have been formed between one single individual who returned in 1920 and no fewer than 800 students in four institutions, three of them being national universities, and one a Christian institution. It is estimated that each of these students made at least eight responses per month for at least eight months—making a total of sixty-four. (Of course the same students made further responses to the Thorndike stimulus presented to them through other teachers.) The upper limit therefore, putting all reactions together, sometimes reached nearly 640. About one third of these students have already started their life work; and from the returns that are available it is estimated that nearly fifty have secured positions as instructors in various normal schools in different provinces, and a few even in such a short time have climbed to the dazzling height of Dean, or Principal. No less than two hundred are already engaged in middle school teaching.

These are statistics concerning the work of only one person; it is also to be remembered that this concerns only one city, Peking. The members of the Thorndike tribe of disciples have wandered into all promised lands in the educational world of China. If the total returns are secured and subjected to the careful analysis according to the principles in *Mental and Social Measurements* the figures will loom up incredibly large, and these figures are of course multiplying right along. It might be easier to make a study of the probable influence of Thorndike in China to-day and in the near future through the records in the office of the Teachers College registrar; because so far almost every student who studied in Teachers College trained under Thorndike or his department has been engaged in teaching, lecturing, writing or "administrating" since he or she returned to China. Some of

the ladies are busily engaged in teaching even after their marriage, following the noble example of Mrs. Hollingworth. There are Chinese students going to T. C. every year and so many coming back every year without giving notice to the world that only until the research students find their names under articles published in educational periodicals, manifestoes or catalogues of institutions, are facts about them available. Whether the younger generation coming out of T. C. are still orthodox Thorndikers or not, it is for those who are still in T. C. to say; but my impression is that the various tribes of Gates, McCall, Hollingworth and Kilpatrick have bred so truly and so effectively that the Thorndike unit-character has been a dominant rather than a recessive. These students are usually faithful followers and are trying to pass on to others the zest for scientific education of which Thorndike is the living embodiment.

To prove this I need only mention a sketch of the history of the McCall tribe in China. Of all the people who were carriers of the Thorndike contagion of measurements and statistical procedure, this tribe, other things being equal, became the most seriously effective. In one summer on the same platform I watched the effective contagion going on among no less than four hundred people including men and women, married and unmarried, consisting chiefly of middle school and elementary school principals and provincial educational inspectors coming from thirteen provinces. After several weeks' inoculation they were sent out with certificates officially signed by McCall and two other of Thorndike's pupils certifying that they were so thoroughly infected that they were permitted to go out and to spread their contagion. Previous to that, eighty students from five institutions went through a much longer incubation period—I use this term with an apology, because I still remember the effective refutation of this heresy in Chapter 10, Vol. II—under McCall and a Chinese pupil of Thorndike. I remember Professor Thorndike telling me in 1919 that McCall was his second self; now I am sure that Thorndike has many more other selves besides McCall, but China was very fortunate to have such an effective disciple of the Thorndike theories and practice as McCall. The list of tests constructed, formulae discovered, visits paid, lectures given, the amount of instinctive pugnacity incited and the responses made, in the short period of one year would arouse the envy of any scientist in education. And the influence is going on after McCall has left.

Of Thorndike's books quite a few copies of the *Briefer Course* in

English have been sold in China. Sometimes I wish that a cheap edition of the three volumes could be published for Chinese consumption. The *Briefer Course* is being translated by a very competent hand, Professor C. W. Luh, head of the Department of Psychology of the National South-Eastern University, Nanking, who has just accepted a call to join the Department of Psychology of Yenching University. It is interesting to note that he, after using several other texts in his teaching, believed that Thorndike's *Educational Psychology* is after all the most substantial book on that subject. What is more interesting is that Dr. Luh has never been to Columbia, he is "only" a Ph.D. of the University of Chicago! This translation is going through the press now. Thorndike's *Principles of Teaching* was translated by Rev. Louis Hodous, formerly a missionary in Foochow, and was published in 1918. The translation represents what a conscientious and able missionary can accomplish through the method of collaboration with a Chinese. Some people think that if it had been done by a Chinese who is competent in three of the elements required for such work, namely, a reliable knowledge in English, a good style in Chinese, and a good knowledge of the subject of educational psychology; and if the book were published by a Chinese publishing house which has a good advertising agency of its own, instead of being published by a Christian literature society, the book would perhaps have received much larger public attention than it has so far. Thorndike's *New Arithmetic* has been translated and adopted by an able mathematician, Prof. Liu Kwang-jao, who is an experienced teacher of mathematics. This book also suffered in the way of circulation because it was not published by a Chinese publishing house, but by a British bookseller which carries on a certain amount of publishing work in China. But these two books are nevertheless being used, although not as widely as other educational books published by Chinese publishing houses. Thorndike's Riverside Monograph on *Individuality* has been translated and published by the Chung Hua Book Company and is having a good sale. Plans are being made to put his *Psychology of Algebra* and *Psychology of Arithmetic* into Chinese in an abridged form. Thorndike's *Education* has been translated by one of my own pupils, but has not yet been published.

To paraphrase his own paragraph on page 425 of Vol. II of the *Educational Psychology*—

"I have tried to give a just statement of facts and probabilities concerning the influence of Thorndike upon the improvement and

efficiency of mental functions of the educators and the students in China. It may, however, be that general prepossessions incline me to a too generous view. As a protection to the reader against such a probability I wish I could close this article by a series of quotations ranging from the most jealous opponents to the spread of Thorndike influence that any reputable psychologist can present, to even more generous statements than the accounts given in this article would suggest."

## THE MIND OF A SCHOLAR

BY HENRY SUZZALLO, PH.D. 1905
President, University of Washington

ALMOST a quarter of a century has passed since I first entered into personal and professional companionship with that group of young scholars, now splendidly mature and still young in all essential things, which constituted the remarkable faculty of the Teachers College in Columbia University. Their personalities seem as vibrant and as eager now as they were then. Only in swiftness, decisiveness and spaciousness of accomplishment do they seem to have changed.

It seems but yesterday that the graduate students waited in their seats in a particular classroom for the coming of a certain young professor of psychology. We knew little of him. The little that we knew passed current as an excuse for the acquaintance of students in neighboring seats, rather than as precise information which had provoked our coming. He had been a student under William James and James McKeen Cattell, and had taught out West somewhere. Some were greatly impressed with the fact that he had experimented with the minds of animals. He was promising, that is what everybody said. And so we chatted and waited for his first appearance.

He finally came, introduced by a staccato tread that sounded his approach down the hall. A dark commanding head appeared at the door. A swift intense glance was cast over the room, followed by a faint shy smile of cordiality. His arms unloaded on the desk a business-like burden of books, papers, and notes. Then an immediate plunge into the subject of the course. Our business had begun—and our acquaintance, our admiration, and our friendship!

This was Edward Lee Thorndike, just promoted from instructor in genetic psychology to be adjunct professor of educational psychology. Twenty-five years of vastly influential thought have passed through his mind since then. Thousands of graduate students have studied with him, and hundreds of thousands of classroom practitioners, school principals, supervisors, superintendents, staff specialists, college instructors, professors, and laymen who have never even heard his voice, have modified their thought and practice in education under the influencing currents of his mind. Few scholars have had a more surpassing power for good in American education than Dr. Thorndike.

The breadth of his influence does not imply an encyclopedic quality of mind, that which could touch every aspect of public education with precise and exhaustive information. Rather it is his ideals, attitudes, and methods in inquiry which gave him a universal appeal. His way of looking at any problem always seemed perfectly disciplined and deeply fundamental. It was his mind which appealed to every kind of consultant whether he had a profound or a transient interest in human nature problems. It was always so with the educationalist, whether teacher or executive officer. It was so with the man of business, the commander of armies or any other responsible person who craved a better way of knowing, selecting, distributing, and managing men and women. Ask them what it was that made even the most casual conversation or the most formal conference with him significant and the answer would always be, "It is his quality of mind."

This is a vague characterization. It neither explains nor describes. It merely denotes. Yet it indicates what we all crave to understand in the scholar with whom we have had any close association. That craving prompts us to hazard a glimpse, even a very imperfect glimpse at the mind of a scholar.

The mind of a brilliant thinker always seems to have the quality of magic about it, though the thinker himself would probably wish this to be the last explanation given. But magic it is to the bystander for whom the flashing processes of mentality are inexplicable. Magic is mystery, and mystery is that which has not been reduced to common wont or scientific explanation.

Professor Thorndike's mind has just this quality of magic for every less gifted acquaintance, whether a beginner in the graduate school, an outsider consulting on a special problem, or a more sophisticated colleague in his study or laboratory. Present him with a problem and his mind goes flashing about like some high bred companion of the

hunt flushing game. He sees a dozen possibilities at once. He suggests them with disconcerting speed, one after the other until the series is complete, each discussed critically with its probable worth and limitation stated. This which seems magic is but the richness of his mental associations. It is based on inherited sensitiveness and exercised to high power by the instinct of venturesomeness. His is an eager, sensitive mind. It always seems active, ever going somewhere, not by placid drifting nor yet by energetic driving, but by a kind of inspired frictionless going. Work seems to be play with him, and play seems always to be moving in the direction of something useful.

One so self-propelling might be endangered by inability to profit greatly from the minds of other men. In ordinary life, the very active, who learn most through their own absorptions, are usually somewhat deaf to the messages of others. People are seldom objective facts to us. They are mainly subjective things that we expect will be adjustable to our own thoughts and acts.

To have the attitude of open-mindedness, tolerance, and courtesy towards other people is at once to save ourselves from a natural and primitive dogmatism which closes up many channels of rich and broadening experience. Here is where character aids intellect. No one that I have ever known is more kindly in his attitude toward the humblest souls he meets than is Thorndike. The foolish questions of a student innocent of facts and the distorted certainties of a crank mind leave him unirritated as they invite him to know more of the normal qualities of ignorance or the pathological aspects of fixed ideas heavily weighted with emotion. The unintentional eavesdropper waiting his turn for conference in the ante-room of Thorndike's office, might be provoked to irritation or laughter as folly and patience converse inside, but not so with the teacher himself. When reminded later, he could laugh at his own predicament, but not at the other's insufficiency. Sensitive and sympathetic with men, they are always respected embodiments of experience to him, something to learn from at first meeting, something to reiterate an inadequately stressed fact on the hundredth contact.

Such accessible and patient qualities in a man might easily destroy him for productive pursuit of the inquries of his own scholarly mind. Not so with Thorndike. He can give himself completely, without fretting, when with human beings, and then disappear to a solitude covering many days and nights, wherein he could follow the courses of an undisturbed mind. Thus, his was a large productive capacity

to which rows of monographs, articles and books bear eloquent testimony that he had not been too much with the world.

Many men with brilliant qualities, who can sense instantly a hundred channels of fruitful thought, fall short of real scholarship. They see at once many tenable working hypotheses, but have none of the traits of intelligent diligence which are requisite for testing the first flashes of thought. Fascinated by their own mental processes, they may even spin complicated webs of reflection, and make useful comment and criticism. But they cannot take out each strand and test it against experience by close statistical analysis or controlled experiment. They cannot combine enchanting, colorful gifts with the more somber and undramatic activities which are needed to garner verifiable truth from preliminary speculation. Just this combination is what makes a scientist of the highest order, and Professor Thorndike affords an example of that combination of traits, working in alternation, which is necessary.

But Dr. Thorndike has brought more than inspired association and intelligent diligence to his work. He has the quality of resourcefulness which has been described in its application to mechanical things as Yankee.

All successful experimental work in the psychological laboratory obviously relies heavily on this capacity. Thorndike's period of interest in animal psychology bears witness to his ingenuity, but not so much as his later researches with statistics as a means. Only a small part of human nature is reducible to experiment; the rest must be taken as it is found, imbedded in complexities that cloud relationships. Here Thorndike has been at his best in arranging his observations of complex phenomena so that results are made simple and significant. In experimental inquiry, one arranges and simplifies the situation itself; in statistical inquiry, one takes a complex situation as it is and arranges and controls the observations so that simplified and significant relations are revealed. This calls for highly ingenious resourcefulness of the intellectual rather than the mechanical sort. In this field of psychological and educational inquiry, Thorndike occupies a supreme position in American scholarship. More than any other of the educational psychologists, he has sponsored statistical method, redevised it for a hundred variable types of inquiry, taught it to his students and headed, with a professional associate or two, the whole movement to give educational thought and practice a scientific and dependable technique.

His contributions as to fact have been enormous, but his greatest contribution has been his method of inquiry and a continuous example of how the scientific spirit may be applied to educational problems.

There is a selfless quality about sound scientific work which Dr. Thorndike possesses in marked degree. It has delivered him from pride of opinion, the trade disease of so many persons in the scholarly professions. He seems not to care who solves a problem, or makes a contribution, so long as it is done. He has broken more than one trail, which promised to lead to illuminating truths and an enhanced personal reputation, only to abandon it to some younger scholar who had betrayed an energetic interest to proceed in that direction. He is as comfortable tossing his fruitful suggestions into a common conference of scholars, where they would be covered by anonymity, as though personal fame had never given him the accolade of distinction.

For popularity of the personal sort, he has no flair. Eager to have scientific fact and conclusion popularized, that it may have a widened use, he has conducted basic researches only to let the simplified and more usable presentations attach to some other man's labor and name. His name on an investigation is a scientist's signature, rather than a personal announcement.

Nothing is more delightful than to feel the living and growing quality of such a man's mind. As years have multiplied his own experiments and inquiries, and countless scholars have deposited new truth on the study tables of the psychological profession, what has once been seen in a meager light must be reviewed in the clearer vision of more truth. How gracefully and impersonally he has always expanded and modified his views, only those who have had the privilege of close association with him can know. We know it as an inspiration, we know it as testimony that, as wisdom is more than knowledge, so scholarship is more than intellection. His is the true scholar's mind —a brilliant and full intellectuality, guided and empowered by a gracious and unselfish character.

# V. Personal Sketches

## ANONYMOUS COMPOSITE FROM MANY FRIENDS AND DISCIPLES

WE (here in England) have been trained into the habit of expecting an annual big book from Thorndike. If ever we are disappointed, we have found that the year following no production was marked by the appearance of two or more volumes, which amply accounts for the seeming lull in activity. There has been nothing for eight or ten months now, so I suppose we may shortly expect a huge work off the press?

Even those of us nearest him don't seem to know all he is doing. He is surely blessed with the ability to keep several lines going at once. Here, while directing the work of the Institute, he finds time to write a book for which ——— is clamoring, besides turning off many magazine articles by the way.

Those who heard him speak at the memorial services, one for his revered teacher William James, the other for his student and colleague Naomi Norsworthy, will never forget his deep and strong emotion, breaking out unexpectedly at times, and moving him to eloquence worthy of the personalities to whom he was paying tribute.

Although I was rather a poor student of Professor Thorndike's, I greatly appreciate his teaching, and I always have a great admiration and affection for him.

He has always been a source of inspiration. He is one to whom many of us owe so much for guidance and help.

Do not the nicknames familiarly and affectionately bestowed indicate something of the esteem in which a person is held? In the first decade of his service, at least, many who felt the value of his common

sense counsel in difficult moments referred to him, among themselves, as Brother Eddie. Many more talk of him as Thorny. Of late he has been styled The Big Chief.

Some of us regret that he has withdrawn of late from the more active work of teaching. It is such a privilege for the younger men and women just to be in contact with him and watch his mind work.

Thorndike is scientific to the *n*th degree and equally human, stimulating and helping the graduate student to master more adequate research technique with a minimum of trial and error.

It is a great honor and pleasure to have the opportunity to make an evaluation of the services of the greatest man we have ever had in Education.

The reading necessary for my small contribution to the commemorative volume has been a veritable "course in Thorndike." I have enjoyed it, though it took an inordinate amount of time to locate one particular reference, and I have surely profited by it.

This article cost me far more effort than I anticipated, the chief difficulty being that of selection. How can one do justice to Thorndike's influence in any field within the limit of words prescribed?

We who have been asked to contribute to this volume feel it is a most useful and happy project, the ultimate completion of which will, I trust, give pleasure to Professor Thorndike as well as to all those of us who have had the opportunity of working with him.

Surely, at the rate Thorndike is producing, your proposed "complete" bibliography will be already out of date by the time it gets into print. Does he not average one publication of some sort a month? However, this annotated bibliography is a monumental thing; copies of it will increase in value as the years go by till they are worth their weight in gold. If only some one, or some committee would see to it to carry on the good work, and do for the next twenty-five years what has now been so laboriously compiled for these last! It would be a unique record, and I recommend it as a valuable project.